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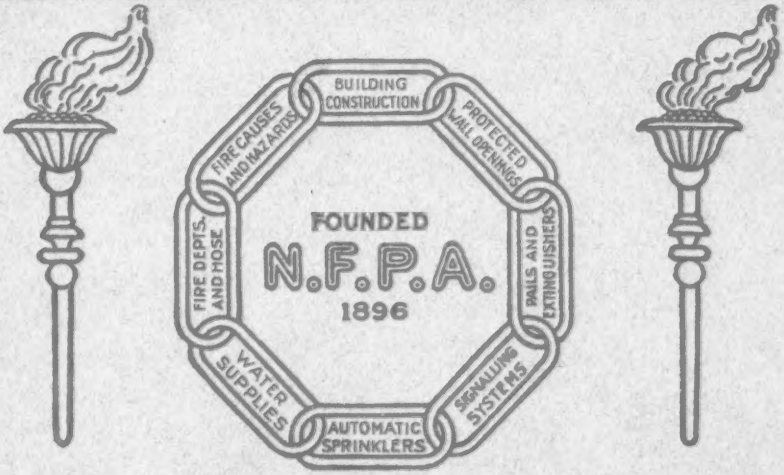
OF THE

NATIONAL FIRE PROTECTION ASSOCIATION



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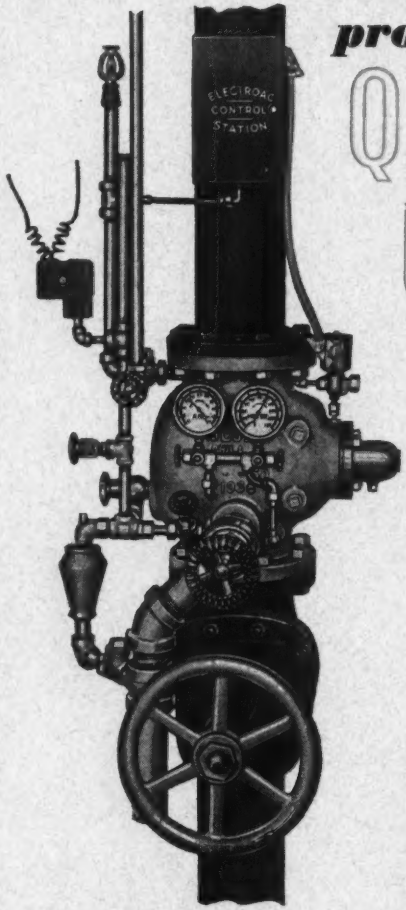

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Finish	Parts
Sensitivity	Trimmings
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Vol. 30 July, 1936 No. 1

QUARTERLY

OF THE

National Fire Protection Association

Subscriptions are accepted only from members of the Association and are charged as a part of the annual dues. Membership is open to anyone interested.

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National Fire Protection Association

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Western Factory Insurance Association.
Western Sprinkled Risk Association.
Western Underwriters Association.
West Virginia Fire Underwriters' Association.
West Virginia Inspection Bureau.

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Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

Portland Flying Service.

The wooden shingle roof conflagration of June 2, 1936 at Peaks Island, a summer resort colony in Casco Bay and within the city limits of Portland, Maine. The buildings burning at the right are the Union House hotel and adjacent stores and dwellings. The wooden shingle roof of the hotel was ignited by sparks from a burning cottage two blocks away. Flying brands carried the fire in all nearly a mile, igniting the wooden shingle roofs which had not been replaced since Portland in 1926 adopted a fire-resistive roofing ordinance. Thirty-five buildings were involved and eighteen were totally destroyed. The single hose company on the island did good work with the limited equipment available. Help arrived from the mainland an hour after the fire started. The Portland fireboat was in drydock when the fire began, but assisted during the later stages of the fire.

The Quarterly

Vol. 30 July, 1936 No. 1

The 40th Annual Meeting. The fortieth annual meeting of the Association, held in Atlantic City in May, was another milestone in the progress of the N.F.P.A. The reports and papers presented, with a stenographic record of the discussions, appear in the Proceedings issued as Part 2 of this QUARTERLY.

The 1936 meeting was similar to those of the past few years, yet marked another step in the gradual evolution of the Association. Changes from year to year are almost imperceptible, but contrasted with the meetings of fifteen or twenty years ago there is a decided difference, reflecting the change in the complexion of the Association. Originally the N.F.P.A. was purely an insurance standard making body, and those active in its affairs were almost wholly men directly concerned with insurance standards. The leaders in the Association from the first realized that the fire waste was not a matter of sole concern to the insurance business, but was of vital interest to the general public. As this idea began to seep into the public consciousness, it was reflected in increased participation in Association affairs by general business, civic officials, and an ever widening group of public-spirited citizens who realized the opportunities for public service in the campaign for the reduction of loss of life and property by fire.

Early meetings of the Association were almost exclusively devoted to the development of technical standards; they resembled large committee meetings in respect to the discussion of technical details. Nowadays technical details are seldom debated at length, for the technical committees usually do their work so well that it is accepted by the convention without question. Only when there is a fundamental question of policy involved, or there appears to be a need for giving a final hearing to some group not satisfied with the committee decisions, is there extended discussion of technical reports. Some members regret the decrease in technical discussions at annual meetings, which always added interest to the convention. The Program Committees have met this situation by arranging for a greater number of informative papers, and through Section meetings and general sessions of popular interest dealing with non-technical subjects.

With a membership as diversified as that of the N.F.P.A., the interests of those attending the annual meetings are necessarily diverse. Some attend

primarily because of the technical committee reports, others are interested in the popular subject sessions, still others come because of the stimulation of personal contact with the leaders of the fire protection fraternity, and lastly there are those who regard a convention largely as entertainment or vacation. The N.F.P.A. meetings are of limited interest to those of the last group, for the Program Committees have always felt that entertainment features should be wholly secondary to the main business of the convention. Men attending our meetings for the first time are always impressed by the seriousness of purpose pervading our meetings, as contrasted with the frivolity of the conventions of many organizations. With as large and diverse a group as ours, no one program can appeal equally to all who attend. A balance must be struck between the various interests, and a program developed which will contain some items to appeal to every group, and most effectively advance the objectives of the Association.

* * * * * *

The Growth of a Practical Idea. In his annual address to the N.F.P.A. convention both this year at Atlantic City and last year at Atlanta, President Harold L. Miner stressed the importance of devoting more attention to reduction of loss of life and property in fires in dwellings. One extremely practical answer to this problem was discussed in an article in the April QUARTERLY, which described a procedure carried out in some cities where firemen called at each home to make a simple inspection of the basement for common fire hazards. Remarkable results in reduced losses have followed such inspections. The idea has been slow to develop because of two factors — one, the feeling that such work would call for an excessive amount of time and manpower, and — two, the impression that such inspections were illegal. That neither of these factors are fundamental objections to the success of this type of work has been amply demonstrated.

A reprint of the QUARTERLY article sent to N.F.P.A. contacts in 450 cities has disclosed a very favorable reaction to this method of fire prevention. According to our present records, cities now doing this work successfully are:

Arlington, Mass.
Baton Rouge
Berkeley
Boston
Brockton
Chelsea
Cincinnati
Cleveland Heights
Dallas
El Dorado, Ark.
Erie
Everett, Mass.
Fitchburg
Fort Collins
Fort Worth
Grand Rapids
Hartford
Helena, Ark.
Irvington
Jonesboro, Ark.
Lincoln, Neb.
Little Rock
Lynchburg
Memphis
Meriden
Middletown, Conn.
Middletown, O.
Newport News
Oklahoma City
Omaha
Parkersburg
Peabody
Pine Bluff
Portland, Me.
Providence
Portsmouth, O.
Salem, Mass.
Saint Paul
Springfield, Mass.
Worcester

Cities planning to launch similar campaigns in the near future are Burlington, Ia., Malden, Mass., Norfolk, Spokane, Toronto and Williamsport.

There are important considerations in such inspection work aside from its real value in reducing loss of life and property. Dwelling house inspections by firemen are valuable good will builders for the fire department and the city government — an extra service without extra cost to the taxpayers.

* * * * * *

The 1935 Fire Loss. The fire loss statistics for 1935, printed on another page of this QUARTERLY, furnish detailed confirmation of the continued downward trend noted in the preliminary estimates published in the January QUARTERLY. As has previously been observed, it appears probable that there will be some increase in losses with expansion of business activities, and that the losses of 1935 are a little lower than we can reasonably expect to maintain under present conditions. There is, however, every reason to hope that a substantial part of the savings of the past ten years can be retained, and that with progressive improvement in fire protection and increasing public appreciation of the significance of the fire waste, the long term trend of losses may continue downward.

There is unfortunately no indication that loss of life and personal injury by fire are following the decrease in property loss. While there are no comparable year by year statistics available to show loss of life by fire, it appears that there has been no substantial decrease in the number of fire casualties in recent years.

* * * * * *

Per Capita Fire Losses. The reporting of city fire losses in dollars per capita is subject to frequent criticism to the effect that conditions in various cities are not the same, and that a comparison based only on population may not be fair. The per capita fire loss figures for 1935 published in this QUARTERLY may be subject to this criticism in some instances. However, in the absence of accurate information on total property values and extent of fire hazards in the various cities, there is available no better index of relative fire experience, and most American cities are sufficiently similar so that there is no great error involved in the use of per capita loss figures. There is always some objection from cities having high per capita losses on the ground that the record of the city is generally good except for some one or two large loss fires. The speciousness of such objections is obvious, for a good part of the national fire loss is contributed by a relatively small number of large loss fires, each one being an exceptional case as far as the individual community is concerned. The encouraging feature is that such protests reflect an increasing realization that a high fire loss is a disgrace, and a desire to improve the fire record of the community.

Meetings of Board of Directors.

Atlantic City, May 11, 1936.

Present.

Albert T. Bell, Chairman
Harold L. Miner, President
George W. Elliott, Vice-President
Frederick T. Moses, Past President
Sumner Rhoades, Past President
Franklin H. Wentworth, Managing Director

Russell Grinnell
W. F. Hickey
C. W. Johnson
Arthur H. Kehoe
Chas. W. Mowry
S. L. Nicholson
C. W. Pierce
D. J. Price
A. R. Small
R. E. Vernor
J. L. Wilds

Business Transacted.

The report of the Chairman of the Board to the annual meeting was read and adopted.

The annual report of the Treasurer was approved.

It was voted to hold the mid-summer meeting of the Board on Monday, June 29.

Providence, June 29, 1936.

Present.

Albert T. Bell, Chairman
Geo. W. Elliott, President
S. D. McComb, Vice-President
Harold L. Miner, Past President
Sumner Rhoades, Past President
Franklin H. Wentworth, Managing Director

H. T. Cartlidge
Russell Grinnell
W. F. Hickey
C. W. Johnson
A. H. Kehoe
W. E. Mallalieu
F. T. Moses
S. L. Nicholson
D. J. Price
C. W. Pierce
A. R. Small
R. E. Vernor

There were also present Percy Bugbee, Assistant Managing Director, and Robert S. Moulton, Technical Secretary.

Business Transacted.

1. The following members were elected officers of the Corporation for the year 1936-1937:

President—George W. Elliott
1st Vice-President—Samuel D. McComb
2nd Vice-President—C. H. Haupt
Secretary-Treasurer and Managing Director—Franklin H. Wentworth
Chairman, Board of Directors—Albert T. Bell

2. It was voted to hold the 41st annual meeting in Chicago during the week of May 10, 1937.

3. The following Program Committee for the 41st annual meeting was appointed: The President, the Managing Director, the Chairman of the Board of Directors, and Messrs. Eugene Arms, John A. Neale, R. E. Maginnis, Frank McAuliffe, C. W. Mowry, R. E. Vernor and C. R. Welborn.

4. Suggestions for the program of the annual meeting and for extending it over an additional day were discussed and referred to the Program Committee.

5. Following his action on recommendation of the Policy Committee recorded in minutes of the last Board meeting relative to the conferences which Member W. E. Mallalieu undertook with a view to reconciling certain differences between the provisions of the N.F.P.A. Flammable Liquids Ordinance and the Fire Prevention Code of the National Board of Fire Underwriters, Mr. Mallalieu reported that no changes of opinion on these differences are evident and no progress towards reconciling these differences may be expected at this time.

6. The Budget for 1936-1937 submitted by the Treasurer was approved and the Finance Committee was authorized to consider the restoration of the Executive Office salary cuts made in 1932 and to act for the Board in the matter according to its judgment.

7. Messrs. Russell Grinnell and David J. Price were selected to complete the Nominating Committee for 1937.

8. The Advisory Committee 1936-1937 was appointed to consist of Albert T. Bell, Chairman, Geo. W. Elliott, Samuel D. McComb, C. H. Haupt and C. W. Pierce.

9. The Association's procedure in the matter of the sponsorship and joint sponsorship of sectional committees of the American Standards Association Building Code project, which have been accepted by the N.F.P.A., was referred to the Committee on Technical Committee Procedure.

10. The status of the New York City Committee was discussed without action.

11. The matter of possible life and fire hazards due to leaks from underground fuel or other oil tanks was referred to the Committee on Flammable Liquids for consideration.

12. The need for development of uniform practice in firemen's training projects was discussed and a committee consisting of Clarence Goldsmith, Chairman, David J. Price and Richard E. Vernor was appointed and authorized to add to its number representatives of interested organizations; this committee to make a thorough study of the matter, work out a routine and details of procedure and report progress to the Board at its winter meeting.

Technical Committee Business.

13. (a) ELECTRICAL. A request was presented for further consideration of the following statement made by the Board in its report to the Association in 1935, on recommendation of a special committee consisting of A. R. Small, Chairman, G. W. Elliott, A. H. Kehoe, C. W. Mowry and S. L. Nicholson:

"The directors are of the opinion that the National Electrical Code is presumed to cover the practical safeguarding of electrical hazards to buildings, their contents and occupants, including primary as well as secondary supply wires and related equipment, and that the nature of such safeguarding is for the Electrical Committee to determine."

The member presenting the matter points out that the statement above referred to related to transformer vaults on the premises of private consumers of electrical energy and those under the sidewalks of public streets as adjuncts to such private buildings, and that the statement is being interpreted to indicate that the Electrical Committee should consider safeguards to the regular occupants of buildings only and not to others or to the general public. The above committee was requested to further consider the above statement originally recommended by it to the Board and to report to the Board at its next meeting the result of such reconsideration.

(b) FLAMMABLE LIQUIDS. Amendments to the Regulations for Safeguarding Dry Cleaning and Dry Dyeing Plants, as adopted in the 1936 report of the committee, were approved, incorporating editorial changes, as follows:

42. Exhaust and ventilating fan motors in ventilating systems shall be of the explosion-proof type approved for Class I, Group D, hazardous locations as defined in the National Electrical Code.

44. Lighting shall be electric incandescent. All wiring shall be in rigid conduit installed in accordance with the rules of the National Electrical Code for Class I hazardous locations. Lighting fixtures, portable lights, switches and other devices shall be of the explosion-proof type approved for Class I, Group D, hazardous locations as defined in the National Electrical Code.

51. Electric motors shall be of the explosion-proof type approved for Class I, Group D, hazardous locations as defined in the National Electrical Code.

52. Motor controllers, overcurrent devices, switches and other electrical devices, if installed in dry cleaning or dry dyeing rooms or other hazardous areas, shall be of the explosion-proof type approved for Class I, Group D, hazardous locations as defined in the National Electrical Code.

53. Delete entirely.

(c) MARINE SECTION. The 1936 report of the Marine Section Committee on Motor Craft was adopted with the following amendments, with authorization to the Marine Section to make further changes in Sections 10, 11 and 13, such further changes to be referred to the Committee on Technical Committee Procedure with power.

2—(a) Change second sentence of first paragraph to—"The handles of all shut-offs at the tanks, whether external or internal, shall be readily accessible. Arrangements shall be provided for operating them from outside the compartments in which the tanks are located, preferably from on deck."

2—(b) Add at end of paragraph—"Such flexible section or a copper loop is recommended for connection between fuel line and engine on all types of mounting."

2—(d) Add at end of paragraph—"Strainers shall be of type opening on top for cleaning screens."

4—(d) Change last sentence of last paragraph to—"The flexible connection shall be placed where it is accessible at all times and internally in contact with all circulating water."

6—Last paragraph next to last line—change constant "1.8" to "2."

7—(b) Change to—"Care shall be taken not to expose gasoline in closed spaces through spilling, drawing off, storage or use in any kind of cleaning, no matter how small the quantity."

7—(f) Change designation of present (f), (g) and (h) to (g), (h) and (i) respectively (g) and insert new paragraph (f)—"In fueling:—before tank fills are opened or (h) gasoline brought on board, all engines, motors and fans shall be shut down, galley fires put out, and all doors, ports, windows and hatches closed. On completion, after hose or cans have been removed, any spillage shall be wiped up and the boat opened. If practicable, it shall remain open for at least five minutes before starting any engine or motor or lighting a fire. No smoking shall be permitted during a fueling operation."

7—new (g) ex (f) In order to conform in grammatical case with other paragraphs of Section, change to "In order to guard against a possible spark during fueling operation, nozzle of the hose or can shall be put in contact with the fill pipe or funnel *before* starting to run in gasoline and this contact shall be kept until the flow has stopped.

NOTE: There is a serious hazard from static discharge unless this rule is observed.

10—(d) Change to—"GASOLINE:—Gasoline stoves shall not be used on boats."

10—(e) Change first sentence of first paragraph to—"LIQUEFIED OR COMPRESSED GAS:—GENERAL:—Vapors from these fuels are generally heavier than air, regardless of their varying rates of evaporation."

10—(f) (2)—Change to—"In a box in the cockpit or on open bridge deck or in a cockpit or open bridge deck transom locker, provided such locker is vented to the outside and is vapor-tight to the compartment below."

11—Delete third sentence and substitute—"Portable kerosene heaters are not recommended."

13—(a) NOTE—add as a second paragraph—"Where explosion-proof apparatus is specified, it shall conform to requirements for such apparatus contained in the National Electrical Code with respect to Class I hazardous locations."

13—(b) 6th line—Substitute words "explosion proof" for words "vapor proof."

13—(i) 2nd paragraph, 3rd line; and 4th paragraph, 2nd line—Substitute words "explosion proof" for words "vapor proof."

15—(f) Table:—change figures in first two items in both columns to three items as follows:

100.....	7.5
140.....	10.
220.....	15.

(d) BLOWER SYSTEMS. The following amendments to the Regulations for the Installation of Power Operated Ventilating, Air Conditioning, Dust,

Stock and Vapor Removal Systems in the 1936 report of the committee were approved.

141. Revise to read: "The term 'ducts' shall refer to tubes, passages or other channels—."

143. Delete second sentence.

169. Revise to read: "Where vent systems for cooking equipment are installed, the provision of steam jets, if available, or an inert gas extinguishing system, is recommended."

201. Add: C. Installation of systems of this class in one and two-family dwellings shall be as specified in Section 280.

211. Substitute "room or enclosure" for "space" in last line.

226. Add new paragraph embodying the text of 285.

232. Substitute "corrosion resistant" for "non-corrosive" in last line.

283. Insert "for conveying conditioned air" after word "Ducts" in first line.

A protest from the National Electrical Manufacturers Association was considered and the Committee on Blower Systems was requested to give further consideration to the changes proposed by N.E.M.A.

(e) MANUFACTURING HAZARDS. Editorial changes in the Regulations for Foam Extinguisher Systems and in the standard for Spark Arresters were approved.

(f) SAFETY TO LIFE. The following amendments to the Building Exits Code and the new section on hotels and apartment houses (Proceedings 1935, page 389) were approved and the publication of a new edition of the Code and its submission to the American Standards Association for approval as a Tentative American Standard were authorized, with authority to the committee to make editorial revisions as necessitated by the changes adopted.

ELEVATORS

703A (New Paragraph) A stairway or some other exit shall be accessible from every elevator entrance landing, and if such stairway or other exit is not visible signs shall be provided to indicate the direction to reach it.

708. NOTE. Add: "except as otherwise permitted by occupancy sections (see pars. 2208 and 2608)."

GENERAL REQUIREMENTS

2012. Substitute for "sprinklered throughout": "completely protected by a system of automatic sprinklers installed and maintained in accordance with the regulations of the National Fire Protection Association."

HOTELS AND APARTMENT HOUSES

2604. Change similar to that in 2012 above.

2605. Omit "except as provided in paragraph (a) of this section" from first sentence. Delete paragraph (a) in its entirety. Retain note.

2626. Insert additional line in table: Masonry wall and joist construction in accordance with 2626A....6 stories.

2626A. (New paragraph) Masonry wall and joist construction buildings may exceed four stories, but not more than six stories in height only if in addition to compliance with all other requirements of this Code they comply with the following special requirements:

(a) First floor shall be of fire-resistive construction unpierced by any openings except elevator or ventilator shafts completely enclosed with walls of fire-resistive construction with self-closing fire doors protecting all openings. Any stairs from basement or cellar shall lead to the outside of the building and not communicate with the first floor area.

(b) Public halls shall be completely enclosed with floors, walls, and ceilings of fire-resistive construction with self-closing fire doors at all openings.

(c) Each apartment shall have access to two independent exits remote from each other so arranged that to reach either exit it will not be necessary to pass through a public corridor or hallway serving the other. Exits shall be so located that it will not be necessary to travel more than 50 ft. from the door of any room or apartment to reach the nearest exit.

13. The report of the Committee on Technical Committee Procedure was discussed and accepted, and the committee authorized to make further routine changes in committee personnel prior to the printing of the 1936 Year Book.

14. COMMITTEE APPOINTMENTS. Various committee appointments were approved. (The revised personnel will be shown in the 1936 Year Book.)

15. An enthusiastic resolution was unanimously adopted thanking Past President F. T. Moses for his generous entertainment of the Board at luncheon at the Squantum Club, and a delightful sail down the bay.

The 1935 Fire Loss.

Fire losses for the United States for the year 1935, as estimated by the National Board of Fire Underwriters, were $248,763,856, the smallest since 1915, and a decrease of $22,433,440, or 8.3 per cent from 1934.

The following table gives the annual fire loss in the United States for sixty-one years, and the chart shows a comparison of losses on a per capita basis for the past ten years. In addition, there have been included tables showing the per capita losses of all cities of 100,000 population or over for a five-year period, and a tabulation of all cities 20,000 population or over where the per capita fire loss exceeded five dollars during the past year. Cities in this class totaled eleven as compared with twenty in 1934. The number of cities in this group were forty-seven in 1931, thirty-four in 1932, ten in 1933, or an average of twenty-four cities for the past five years. In at least eight of the eleven instances the high per capita loss figure was attributable to one or two large fires. Five of these cities had fires causing losses of $250,000 or over and are shown on the Annual Conflagration Map appearing on page 193 of the January, 1936, QUARTERLY. The cases of Stockton, Calif., with a $400,000 feed mill fire, and Steubenville, Ohio, with a $250,000 mercantile district fire, are typical.

Annual Fire Losses in the United States for Sixty-one Years.

Year	Property Loss	Year	Property Loss	Year	Property Loss
1875.....	$78,102,285	1895.....	$142,110,233	1915.....	$172,033,200
1876.....	64,630,600	1896.....	118,737,420	1916.....	258,377,952
1877.....	68,265,800	1897.....	116,354,575	1917.....	289,535,050
1878.....	64,315,900	1898.....	130,593,905	1918.....	353,878,876
1879.....	77,703,700	1899.....	153,597,830	1919.....	320,540,399
1880.....	74,643,400	1900.....	160,929,805	1920.....	447,886,677
1881.....	81,280,900	1901.....	165,817,810	1921.....	495,406,012
1882.....	84,505,024	1902.....	161,078,040	1922.....	506,541,001
1883.....	100,149,228	1903.....	145,302,155	1923.....	535,372,782
1884.....	110,008,611	1904.....	229,198,050	1924.....	549,062,124
1885.....	102,818,796	1905.....	165,221,650	1925.....	559,418,184
1886.....	104,924,750	1906.....	518,611,800	1926.....	561,980,751
1887.....	120,283,055	1907.....	215,084,709	1927.....	472,933,969
1888.....	110,885,665	1908.....	217,885,850	1928.....	464,607,102
1889.....	123,046,833	1909.....	188,705,150	1929.....	459,445,778
1890.....	108,993,792	1910.....	214,003,300	1930.....	501,980,624
1891.....	143,764,967	1911.....	217,004,575	1931.....	451,643,866
1892.....	151,516,098	1912.....	206,438,900	1932.....	400,859,554
1893.....	167,544,370	1913.....	203,763,550	1933.....	271,453,189
1894.....	140,006,484	1914.....	221,439,350	1934.....	271,197,296
				1935.....	248,763,856

NOTE:—Previous to 1916 figures obtained from the records of the New York *Journal of Commerce*, deducting the Canadian losses. Subsequent years are based on returns to Actuarial Bureau of the National Board of Fire Underwriters, adding 25% for unreported and uninsured losses. The figure for 1935 is based on estimates made by the Actuarial Bureau, and includes 30% added for unreported losses.

Losses in Cities of 20,000 Population or Over.

Losses in cities of 20,000 population and over as reported by the fire department officials show a decrease of 15.8 per cent from 1934. The rate of decrease in city losses was nearly twice that of the entire country for the year. The per capita fire loss for this group of cities, for the past ten years, has averaged only 70.6 per cent of the per capita loss figure for the entire country and reflects the results of the stronger fire protection in the larger communities of the country. The 1935 per capita fire loss for the country as a whole was $1.95 as compared with $1.33 average for the 469 cities of 20,000 population or over. The per capita and total loss figures for cities of over 20,000 population and for the United States for the past ten years are shown on the chart on the next page.

Cities in Which Loss Exceeded $5.00 Per Capita in 1935.

**Salem, Ore.....	$35.23	****Peabody, Mass.....	6.97
Peoria, Ill.....	31.93	**Lewiston, Me.....	6.28
LaCross, Wis.....	10.18	Concord, N. H.....	5.73
**Steubenville, Ohio.....	7.51	***Chelsea, Mass.....	5.44
**Stockton, Calif.....	7.47	Tacoma, Wash.....	5.06
Shamokin, Pa.....	7.14		

NOTE: Asterisks indicate the number of years in which the city has been in this class during the five-year period ending December 31, 1935.

Per Capita Fire Losses of Cities Over 500,000 Population.

	Population	1931	1932	1933	1934	1935	Five-Year Average
New York, N. Y.*	7,602,000	$3.24	$3.38	$1.88	$1.75	$1.69	$2.39
Chicago, Ill.	3,475,000	2.73	3.42	1.64	3.18	1.07	2.41
Philadelphia, Pa.	1,950,000	2.12	2.09	1.19	1.10	1.51	1.60
Detroit, Mich.	1,560,000	2.30	1.82	1.37	1.47	1.23	1.64
Los Angeles, Cal.	1,351,000	1.82	1.14	.85	.65	.77	1.05
Cleveland, O.	922,000	2.61	2.26	.94	1.84	1.32	1.79
St. Louis, Mo.	900,000	1.77	1.67	1.70	1.68	1.13	1.59
Baltimore, Md.	844,000	1.53	3.29	1.68	.84	.94	1.66
Boston, Mass.	795,000	5.14	5.27	2.93	2.94	2.56	3.77
San Francisco, Cal.†	710,000	...	...	...	...	...	...
Pittsburgh, Pa.	700,000	1.61	1.25	.64	.96	.97	1.09
Milwaukee, Wis.	615,000	1.60	1.23	2.23	1.05	.95	1.41
Buffalo, N. Y.	599,000	2.20**	2.17	1.69	2.25	1.04	1.87

†Does not report its losses.

*These figures are based on losses paid in New York City by the subscribers to the Actuarial Bureau of the National Board of Fire Underwriters. The fire department estimates for these years were considerably lower.

**Incomplete. Does not include Buffalo Armory fire, involving loss of at least $2,500,000.

Cities from 400,000 to 500,000 Population.

	Population	1931	1932	1933	1934	1935	Five-Year Average
Washington, D. C.	497,000	$ .75	$ .72	$ .80	$ .48	$ .90	$ .73
Minneapolis, Minn.	490,000	3.06	2.33	2.35	1.75	1.88	2.27
New Orleans, La.	472,000	1.42	1.47	.92	.65	1.32	1.16
Cincinnati, O.	467,000	1.89	1.37	1.30	1.19	.56	1.26
Newark, N. J.	444,000	2.82	2.14	1.38	1.19	1.69	1.84
Kansas City, Mo.	437,000	2.71	4.05	1.72	1.96	1.91	2.47

Cities from 300,000 to 400,000 Population.

	Population	1931	1932	1933	1934	1935	Five-Year Average
Seattle, Wash.	398,000	$2.94	$2.38	$1.16	$1.58	$1.11	$1.83
Indianapolis, Ind.	370,000	1.44	1.19	1.02	1.23	1.15	1.21
Houston, Tex.	351,000	3.43	4.86	2.39	1.34	1.23	2.65
Louisville, Ky.	343,000	3.19	1.53	1.93	1.57	.60	1.76
Rochester, N. Y.	328,000	1.65	1.26	1.63	1.16	.97	1.33
Denver, Col.	325,000	1.25	2.18	1.00	1.11	1.33	1.37
Jersey City, N. J.	325,000	1.14	.53	.42	.28	.38	.55
Portland, Ore.	320,000	3.04	2.21	2.14	1.98	1.56	2.19
Toledo, O.	310,000	3.70	2.06	1.10	1.17	.66	1.74
Dallas, Tex.	301,000	5.59	4.47	3.18	2.86	1.96	3.61

Cities from 200,000 to 300,000 Population.

	Population	1931	1932	1933	1934	1935	Five-Year Average
Columbus, Ohio	298,000	$ .40	$ .65	$ .39	$ .71	$ .82	$ .59
Atlanta, Ga.	297,000	2.48	1.38	2.17	.67	.84	1.51
St. Paul, Minn.	290,000	2.70	2.67	1.93	2.22	2.63	2.43
Oakland, Cal.	286,000	2.83	1.44	1.39	1.30	1.09	1.61
Memphis, Tenn.	267,000	4.03	3.19	2.35	2.23	.82	2.52
Birmingham, Ala.	265,000	3.09	1.93	1.28	7.95	2.20	3.29
Providence, R. I.	259,000	3.63	1.39	.66	.77	.96	1.48
Akron, O.	250,000	1.18	.84	.91	.65	.44	.80
San Antonio, Tex.	247,000	1.05	1.44	.64	.41	.60	.83
Omaha, Neb.	225,000	2.56	2.87	3.77	1.20	1.33	2.35
Dayton, O.	213,000	1.07	1.73	2.33	1.02	.96	1.42
Syracuse, N. Y.	210,000	2.50	2.49	1.48	2.31	.51	1.86

Cities from 150,000 to 200,000 Population.

	Population	1931	1932	1933	1934	1935	Five-Year Average
Worcester, Mass.	198,000	$5.14	$4.62	$1.66	$2.35	$1.72	$3.10
Richmond, Va.	190,000	1.24	.65	1.28	.46	.25	.78
Oklahoma, City, Okla.	184,000	1.15	.77	.38	.46	1.00	.75
Youngstown, O.	175,000	1.64	.89	.47	1.23	.79	1.00
Fort Worth, Tex.	175,000	6.55	3.96	2.92	2.28	2.68	3.68
Grand Rapids, Mich.	169,000	2.05	.67	.88	.48	.77	.96
Hartford, Conn.	164,000	1.87	1.99	.68	1.19	.91	1.33
New Haven, Conn.	163,000	2.47	1.86	1.75	2.72	1.33	2.03
San Diego, Calif.	160,000	.57	.96	.70	.97	.81	.80
Nashville, Tenn.	160,000	4.55	4.98	3.96	2.50	2.09	3.61
Flint, Mich.	156,000	.89	1.17	.96	1.28	.69	1.00
Long Beach, Cal.	155,000	1.11	.43	.91	.38	.42	.65
Springfield, Mass.	150,000	3.20	4.14	1.57	2.15	1.40	2.49

Cities from 125,000 to 150,000 Population.

	Population	1931	1932	1933	1934	1935	Five-Year Average
Bridgeport, Conn.	147,000	$1.05	$1.98	$ .47	$ .88	$1.16	$1.11
Des Moines, Iowa	144,000	1.50	1.42	1.41	1.49	1.26	1.42
Scranton, Pa.	144,000	2.10	2.84	1.76	2.84	.99	2.11
Tulsa, Okla.	142,000	.87	.84	.84	.70	.94	.84
Yonkers, N. Y.	141,000	2.18	1.68	1.72	.61	1.06	1.45
Salt Lake City, Utah	140,000	3.07	1.52	1.73	.79	2.09	1.84
Jacksonville, Fla.	139,000	8.64	4.21	2.73	2.00	1.18	3.75
Paterson, N. J.	138,000	3.50	2.41	1.83	2.00	.50	2.05
Norfolk, Va.	130,000	9.09	3.12	2.42	3.12	2.63	4.08
Miami, Fla.	130,000	1.20	1.28	.75	1.14	.72	1.02
Albany, N. Y.	127,000	4.24	1.73	1.69	1.35	1.27	2.06
Kansas City, Kans.	125,000	.86	2.69	.68	3.79	1.81	1.97

Cities from 100,000 to 125,000 Population.

	Population	1931	1932	1933	1934	1935	Five-Year Average
Trenton, N. J.	123,000	$2.70	$1.12	$2.04	$ .51	$ .40	$1.35
Elizabeth, N. J.	123,000	1.83	2.22	1.19	.56	.59	1.08
Spokane, Wash.	121,000	2.55	1.74	2.21	.86	1.67	1.81
Chattanooga, Tenn.	120,000	2.91	1.27	2.63	1.23	.92	1.79
Peoria, Ill.	120,000	2.34	3.29	.89	1.27	31.93	7.94
Camden, N. J.	119,000	...	1.86	1.68	1.49	1.28	1.58
Cambridge, Mass.	118,000	4.14	3.57	1.29	1.28	2.12	2.48
Erie, Pa.	117,000	1.78	1.86	.68	.51	3.27	1.62
Tampa, Fla.	117,000	2.32	1.94	.87	.71	2.92	1.75
Fall River, Mass.	117,000	1.69	2.36	2.16	2.62	1.06	1.98
Fort Wayne, Ind.	116,000	1.56	1.02	.69	.74	.43	.89
Reading, Pa.	114,000	3.67	.76	1.10	.35	1.21	1.42
Wichita, Kans.	113,000	.76	1.13	.95	.65	.81	.86
Knoxville, Tenn.	111,000	1.29	1.18	.66	.98	.70	.96
New Bedford, Mass.	110,000	1.50	.87	.83	.61	.42	.85
Wilmington, Del.	110,000	2.35	2.01	2.37	1.12	1.32	1.83
Tacoma, Wash.	108,000	2.93	2.51	1.85	4.70	5.06	3.41
Evansville, Ind.	107,000	1.76	1.97	1.13	1.19	.78	1.37
Utica, N. Y.	105,000	6.59	4.09	1.84	1.69	1.02	3.05
Gary, Ind.	105,000	2.64	3.54	.61	.34	.57	1.54
Canton, O.	104,000	1.12	.97	.57	.65	.52	.77
South Bend, Ind.	104,000	.91	1.20	.75	.77	1.79	1.08
Somerville, Mass.	103,000	2.81	2.54	2.40	3.29	1.14	2.44
El Paso, Tex.	103,000	3.76	1.02	.50	1.23	.31	1.36
Lynn, Mass.	101,000	4.52	4.71	2.85	1.94	4.42	3.69
Duluth, Minn.	101,000	3.66	3.48	2.01	1.52	1.65	2.46
Lowell, Mass.	100,000	2.41	2.46	2.08	1.49	1.34	1.96
Waterbury, Conn.	100,000	2.15	2.33	1.98	1.51	1.04	1.80

U. S. Losses Up for First Part of 1936.

The fire losses for the United States for the first five months of 1936 were $135,083,447, which is $17,122,481, or 14.5%, more than for the same period last year, according to estimates prepared by the National Board of Fire Underwriters.

	1933	1934	1935	1936
January	$35,547,565	$28,002,583	$23,430,504	$27,729,930
February	36,661,481	31,443,484	25,081,625	30,909,896
March	35,321,248	31,312,359	24,942,703	29,177,406
April	27,825,970	22,028,943	23,267,929	25,786,835
May	24,338,714	25,271,459	21,238,205	21,479,380
Total—5 months	$159,694,978	$138,058,828	$117,960,966	$135,083,447

Canadian Fire Losses, 1935.

Canadian fire losses for the year 1935 amounted to $23,221,521, sustained in 42,468 fires, according to statistics furnished by J. Grove Smith, Dominion Fire Commissioner. These figures show another reduction in losses and continuation of the downward trend started in 1932. The reduction in the amount of property loss in 1935 amounted to $2,216,319, or 8.7% less than the 1934 loss, which was in turn 22.1% less than the loss for the previous year. The Dominion fire loss in 1935 was but 49.3% of the 1931 loss. The number of fires reported showed a reduction of 1154 from 1934. Loss of life from fire increased from 268 in 1934 to 293 fatalities in 1935. This was the greatest number in any year since 1930.

A Decade of Fire Losses in Canada.

Year	Property Loss	Per Capita	Year	Property Loss	Per Capita
1926	$38,295,096	$4.15	1931	$47,117,334	$4.54
1927	32,254,084	3.29	1932	42,193,815	4.06
1928	36,402,018	3.79	1933	32,676,314	3.15
1929	47,499,746	4.85	1934	25,437,840	2.44
1930	46,109,875	4.70	1935	23,221,521	2.12

Losses by Provinces.

	Population	Loss, 1934	Per Capita Loss, 1934	Loss, 1935	Per Capita Loss, 1935
Alberta	780,000	$1,177,370	$1.60	$1,087,614	$1.39
British Columbia	735,000	1,988,501	2.86	1,941,702	2.64
Manitoba	739,000	1,195,160	1.70	1,040,135	1.40
New Brunswick	429,000	823,523	2.02	1,058,704	2.46
Nova Scotia	527,000	1,219,215	2.38	1,155,759	2.19
Ontario	3,596,000	10,040,144	2.92	8,164,350	2.27
Prince Edward Island	89,000	191,103	2.17	167,303	1.88
Quebec	3,062,000	7,567,975	2.65	7,404,965	2.41
Saskatchewan	978,000	1,233,335	1.33	1,188,694	1.22
Not reported	.....	1,514	...	12,295	...
Total	10,949,000	$25,437,840	$2.44	$23,221,521	$2.12

Population Group Loss Classification.

Group	Total Loss, 1935	Per Capita
Cities over 10,000 population	$7,015,836	$1.06
Towns 5,000 to 10,000 population	1,098,139	2.54
Towns 1,000 to 5,000 population	1,256,897	2.43
Villages under 1,000 population	2,863,207	5.49
Rural districts	10,987,442	2.30
Total	$23,221,521	$2.12

Occupancy Record.

	1935		Ten Years 1926-1935	
	No. of Fires	Loss	No. of Fires	Loss
Dwellings (all classes)	30,676	$8,213,395	273,365	$104,382,639
Farm property (excluding dwellings)	3,002	2,926,767	41,026	42,198,204
Retail and wholesale stores	3,936	5,731,894	47,998	103,266,815
Manufacturing properties	681	4,086,815	9,516	62,113,034
Churches, schools and institutions	442	980,908	5,489	26,885,219
Miscellaneous property	3,731	1,281,742	36,945	22,361,732
Total	42,468	$23,221,521	414,339	$350,207,643

Statistics of Fires in Canadian and Foreign Cities, 1935.

Reported by National Board of Fire Underwriters. Losses are figured at par exchange.

City	Population	Per Capita Loss
Canada		
Hamilton	154,000	$2.47
Montreal	1,198,000	1.69
Toronto	638,000	1.23
Vancouver	245,000	2.04
Winnipeg	225,000	.97
Great Britain		
Birkenhead	151,000	.32
Birmingham	1,033,000	1.19
Bolton	177,000	.38
Bradford	298,000	1.13
Cardiff, Wales	222,000	1.74
Edinburgh, Scotland	461,000	.96
Glasgow, Scotland	1,127,000	.50
Kingston-on-Hull	324,000	.89
Leeds	485,000	.93
Liverpool	856,000	.55
London	4,397,000	1.20
Manchester	776,000	.84
Southampton	177,000	1.69
Stoke-on-Trent	275,000	.73
York	87,000	1.02
Europe		
Vienna, Austria	1,854,000	.09
Bordeaux, France	263,000	.48
Venice, Italy	271,000	.15
Oslo, Norway	264,000	3.42
Stockholm, Sweden	526,000	.89
China		
Shanghai	3,684,000	.12
New Zealand		
Wellington	115,000	.93

Fire Safety in the Motion Picture Industry.

By Henry Anderson,
Manager, Insurance Department, Paramount Pictures, Inc.

Since 1928 the 376 film exchanges that are members of the Motion Picture Producers and Distributors of America ("Hays Organization") had a total of only nine fires. The total loss in these nine fires was $1437.50, making an average of one fire and $160 loss per year. We are proud of this record and are pleased to share the credit for it with the National Fire Protection Association.

It is most fortunate that our industry and the N.F.P.A. meet on common ground. Our industry has, we believe, followed all of the ideals and standards so long and so ardently advocated by the N.F.P.A. The results speak for themselves.

While this article relates principally to distribution of motion picture film through exchanges, it may be helpful to touch upon the other two activities, namely, production in studios and exhibition in theatres.

The Introduction of Sound.

Radical changes and general improvement in the motion picture industry resulted from the introduction of sound. In studios, the expense and exacting technical requirements of installing sound recording equipment placed production in more responsible hands. In exchanges, it necessitated greater care in handling film to avoid damage to the sound track.

Tremendous improvements in theatres have resulted from the increased revenue brought about by the introduction of sound. Almost invariably when sound was installed, the theatre was completely redecorated, refurnished and modernized. In many cases a new and improved booth was constructed to accommodate the sound equipment and larger projectors. The qualifications of motion picture projectionists have been raised because of the additional technical knowledge required to operate the elaborate sound equipment.

Sound pictures were originally made by running a phonograph disc in synchronism with the ordinary film, and the method was still employed until quite recently. The sound is now photographed on the picture film, and when the film is run through the projection machine a photo electric cell and an elaborate system of apparatus convert the photograph of the sound at the side of the film into sound.

This article was presented as a paper at the 40th Annual Meeting of the National Fire Protection Association, Atlantic City, May 11-14, 1936. For discussion see Proceedings (printed as Part 2 of the QUARTERLY), page 89.

Temporary buildings at Paramount Studios and a piece of apparatus from their own fire department.

In order to place a sound track on film and retain the standard film width, it is necessary to make the picture part narrower than on the old silent film. When making a picture two separate negatives are generally made — one for the picture or action and one for sound. Sometimes parts of pictures are taken as silent pictures and sound effects added later. Positives are then made so that the various shots or parts wanted may be selected and assembled into a continuous picture or "cutting print." The complete negative is made by matching the negative parts and accompanying sound record with the cutting print. This negative is used for making the quota of prints, say from 200 to 300.

Studio Operation.

There is nothing hit-or-miss about the physical operation of a studio. It involves almost every trade, science and profession, and requires capable engineers to carry on the actual work.

Interruption to operations is the contingency most dreaded because of enormous overhead and salaries, and the necessity for completing pictures on schedule. Fire protection and fire prevention are, therefore, given first consideration. There is no such thing as moral hazard here.

At Paramount Studios, for example, we are completely equipped with automatic sprinklers and central station supervisory and alarm service. We have our own uniformed fire department and motor apparatus. This department makes regular inspections, and its recommendations are carried out by the management. A thoroughly trained fire brigade made up of regular employees supplements the uniformed force.

The film shipping department in a St. Louis exchange, showing various fire protection equipment and appliances.

We also have the most complete hose protection possible. Due to the dry climate in Hollywood, there is a decided hazard resulting from embers or sparks landing on roofs. Sufficient hose is provided to reach every square foot of roof, studio, and lot areas. Both 1½ in. and 2½ in. hose are used. Permanent ladders are provided for access to the roofs. Monitor type nozzles of large diameters are provided in case of fire on the lot or in the sound stages. We have found by test that we can demolish almost any set with them.

Fire protection of the sound equipment is a serious problem. This tremendously expensive, complicated and highly delicate system of wiring, coils, tubes, condensers, etc., is even more delicate than that of a telephone central office. The carbon dioxide type of extinguisher has been adopted because of absence of moisture or corrosive properties. Tarpaulins to prevent water damage and other accessories, such as asbestos gloves for beating out burning insulation and handling hot wires, are provided. Dust is one of the hazards in the film laboratory, and therefore hospital cleanliness is required.

Film Exchanges.

Motion picture exchanges are circulating libraries for film and are located in principal cities to serve the surrounding territory. They must be run in an orderly manner and on absolute schedule so that films are sure to arrive at theatres as advertised. Interruption of operation by fire would be disastrous.

Each exchange receives its quota of prints from the laboratory, and then

Interior of a typical film vault. All films are in metal containers. Note vapor proof light and metal step ladder. The sprinkler equipment is not visible in this picture.

keeps them moving from the exchange to the theatres and back to the exchange, and so on. An attempt is made to have each film returned to the exchange for examination and repair after each booking. Any splices made at the theatres are made over. This adds to the fire safety of the theatres served.

Practically all of the motion picture producers and distributors are members of the Motion Picture Producers and Distributors of Amercia, Inc., popularly known as the Hays Organization. Appreciating the service the N.F.P.A. might give to the industry, the Hays Organization about 15 years ago established a Conservation Department. This department supervises and advises upon all matters relating to fire hazards in the industry and makes regular inspections of all exchanges. The amazing fire record of the industry is without doubt the result of the work done by this department. Mr. Arthur S. Dickinson is in charge of this department, and it has been his energy and enthusiasm that have been the driving force behind this program.

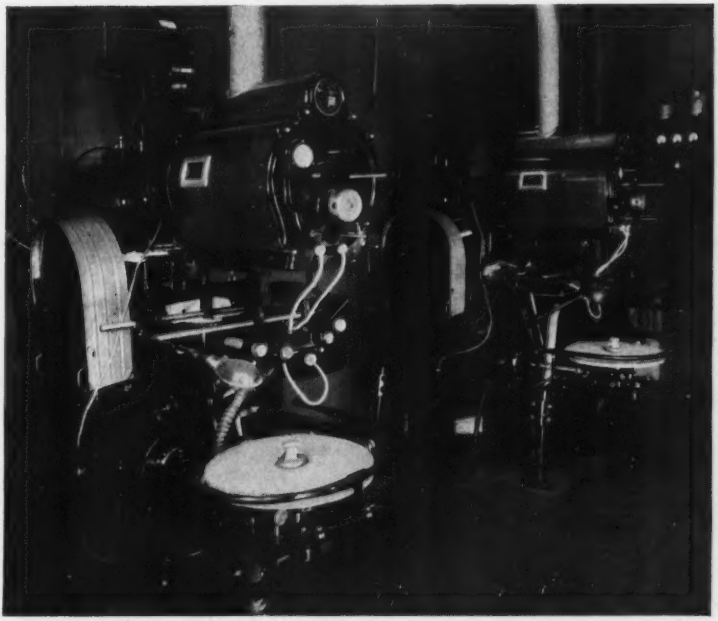
A total of 376 out of the approximately 450 exchanges in the United States and Canada are members of the Hays Organization. Member exchanges represent an investment of many millions of dollars and serve approximately 20,000 theatres. They handle about 30,000 miles of film daily.

An inspection room of a modern film exchange, showing vapor-proof lights, automatic sprinklers, sand pails, mesh screen over radiators, metal window frames, metal chairs and tables, side-wall pilot lights, and scrap film container. There are two exits, one to the shipping room and one to an alley.

A novel arrangement has been worked out for inspecting exchanges. A committee of three or more members, each representing a different company or producer, is appointed in each city. This committee is usually accompanied by an officer of the fire department and secretary of the Film Board of Trade, and inspects every exchange in the city once a month. With each representative (such as one each from RKO, Fox, and Paramount) inspecting and criticizing his competitors' exchange, a good check-up on conditions is obtained. Exchange managers take pride in avoiding criticism by competitors, and perhaps each competitor is human enough to take satisfaction in criticizing the others.

Instruction cards based largely on N.F.P.A. regulations are printed and posted in each exchange. There are separate instructions for inspection rooms, shipping rooms, poster departments, and business offices. A fire drill is invariably held during an inspection, but most exchanges hold a drill on their own initiative once a week.

Last year 4500 monthly inspections were made, and reports on them turned in to and followed up by the Conservation Department. The director of the department personally inspected 180 exchanges. Each year a trophy in the form of a lighthouse symbolizing safety is awarded to the exchange with the best record.



Interior of a projection booth at a Chicago film exchange.

Fire Record of Film Exchanges.

Probably no industry or branch of any industry can boast of a fire record such as that of the motion picture industry since 1928 as recorded below. Records prior to 1928 are not available.

1936—No fires have occurred in exchanges of members.

1935—Two fires with a total loss of $8, no film involved.

1934—One fire with a loss of $148 originated in the inspection department of a member exchange in Dallas, Texas. It is reported that in some manner a parlor match had accidentally dropped into a can of film prior to delivery to the exchange and set fire to the contents. The automatic sprinkler system functioned quickly and effectively. The seven inspectresses in the room left quietly and speedily and no injuries resulted.

1933—No fires occurred in exchanges of members.

1932—Three fires in office sections of member exchanges. The losses were $25, $15, and $1.

1931—No fires occurred in exchanges of members.

1930—One fire with a loss of $15; 600 ft. of film destroyed.

1929—One fire with a loss of $1200, caused by defective wiring in an advertising department; no film involved.

1928—One fire with a loss of $25. Part of a reel of film was burned as it was being rewound.

Other Activities of the Industry.

The industry does not stop at the doors of its own exchanges in active fire prevention, but makes an effort to follow the film throughout its journey. For example, last year the entire industry was circularized as to the methods for disposal of scrap film. Arrangements were also made so that theatres can send their scrap film to exchanges for disposal.

Through its Conservation Department the industry has tightened up on non-professional use of film. At one time nitrocellulose film was pretty generally used in schools, churches, lodges and similar institutions. Questionnaires were recently sent to about 4000 of these non-theatrical institutions to obtain a record of type of equipment used, type and construction of projection booth, and experience of the projectionists. About 3000 institutions were approved for continued exhibition of film.

Each non-theatrical institution is now required to obtain the consent of a recognized state or local fire official before any exchange will supply it with film. Motion picture distributors have been instrumental in bringing about the installation of 360 standard fire-resistive booths in institutions not previously having proper facilities. State fire marshals, fire insurance rating bureaus, and chiefs of fire departments have coöperated splendidly with the industry.

There are now some 18,000 accounts in the United States served with picture programs from one to seven times a week. The average number of film shipment per week to and from exchanges and exhibitors is about 240,000. Most shipments of film and advertising accessories are handled by special motor truck film delivery services handling film only. Other methods of transportation used are: railway express, parcel post, and messenger. Shipments are made in metal I.C.C. containers labeled to indicate their contents. Distributors require truckmen handling their film to present a certificate showing that they carry cargo insurance. This is not solely because we need insurance as such, but in order to assure ourselves that only the more responsible truckmen will handle film. It has been our feeling that only responsible truckmen will be able to obtain insurance.

The motion picture industry is proud of its new exchange buildings erected during the past few years. In 1935, modern fire-resistive buildings were erected in Atlanta, Oklahoma City, Los Angeles, Washington, D. C., Minneapolis, Boston, Cleveland, Detroit, Charlotte, Memphis, and Toronto. All the exchanges are modern in every respect, and many are air conditioned.

The question of replacing nitrocellulose film with cellulose acetate film frequently arises. The motion picture industry uses nitrocellulose film because cellulose acetate film will not stand up under the severe conditions to which film is subjected. The average print now fulfills 40 playing dates, or about 200 showings. If cellulose acetate film were used, not more than 10 playing

dates or 50 showings could be made, and it would therefore be necessary to make four times as many prints as are now being used on any given picture. Chemists of the film manufacturers have not yet found a way to stop cellulose acetate film from warping and buckling after being subjected to the high intensity arc lights which are generally used in theatres.

The introduction of the 2000-foot reel will reduce further the fire hazard in theatres and exchanges. The modern motion picture booth is provided with every possible safeguard. In the responsibly operated theatre, fire is dreaded more than anything else, and every precaution is taken to prevent fires and to handle them if they should occur.

Through centralized control of fire prevention work such as that carried on by the Conservation Department of the Motion Picture Producers and Distributors of America, any industry can reduce its fire hazards and fire losses. It is not an expensive thing to do, and requires little extra effort. Almost always as a result of fire prevention campaigns there seems to follow an improvement in other operating conditions. We hope that other industries will try our plan. Once started, it may extend through industry in general.

Lighthouse trophy awarded each year to the exchange having the best fire prevention record.

Municipal Fire Apparatus Budget Programs.

By Percy Bugbee.

It is difficult to arrive at an exact figure as to the total amount of municipal fire apparatus now in service in fire departments in the United States. The best estimate that we can make would indicate that there are approximately 36,000 pieces of motor fire apparatus now in use. Of these, 22,000 are pumpers of various kinds, about 7500 are hose and combination trucks, about 6000 are ladder trucks, and the balance miscellaneous apparatus of various types.

It is possible to get a fairly accurate record of the amount of equipment in the 471 cities over 20,000 population in the United States. According to recent estimates, these cities have 7717 pieces of motor fire apparatus, of which 4001 are pumpers, 1657 are hose and combination trucks, and 1678 are ladder trucks. Also in this class of cities there are 132 rescue trucks, 71 water towers, and 52 fire boats. It is interesting to observe that only 18 per cent of the pumpers are in the 471 cities over 20,000 population and the other 82 per cent are in the 12,000 cities and towns under 20,000 population which have organized fire departments. It is estimated that some 40,000,000 feet of fire hose of various sizes is in use on the fire trucks in the United States.

Although the total figures are impressive and represent a considerable expenditure for fire apparatus, it is well to remember that only a comparatively small proportion of the fire department budget, particularly in the larger cities, goes for the purchase of fire apparatus. In most cases from 5 to 10 per cent of the fire department budget is spent for new apparatus and maintenance of existing apparatus. Most of the other 90 to 95 per cent of the fire department budget is for salaries.

According to the United States Census figures, the following number of pumping engines have been purchased during the past ten years:

1926	1,011	1931	666
1927	971	1932	267
1928	1,015	1933	227
1929	997	1934	339
1930	827	1935	471

The total number of engines purchased for the ten-year period is 6791. If our estimate of approximately 22,000 pumpers in service is correct, this would indicate that only about one-third have been purchased in the last ten-year period and that much of the present equipment is over twenty years old.

It is difficult to establish any definite figure which will represent the length of life of a piece of fire apparatus. The life of the apparatus depends on a number of factors. The most important is maintenance. If the apparatus

is located in a congested district of a large city and subject to a large number of runs and to many long periods of pumping at full load, it will wear out sooner than apparatus in a less congested area with only a few runs a year. The condition of roads, climatic conditions, the topography, and other factors enter into the situation. Probably as good an average figure as could be suggested for the length of life of any piece of fire apparatus would be in the neighborhood of 15 years. It should be even shorter for apparatus built prior to the advent of present day traffic conditions, which apparatus obviously is not provided with the modern requisites for safe driving (*e.g.*, four-wheel brakes). All too many of the present pieces of fire apparatus in use have been in service longer than that length of time.

Replacement of Obsolete Pumpers.

To replace the present number of pumping engines over a 15-year period would require the purchase of 1460 pumpers each year. It will be noted from the Census figures that in no year of the ten years given were there more than a little over 1000 pumping engines purchased, and during the years of 1932, 1933 and 1934 only two or three hundred pumpers were purchased. This would indicate that a large number of pieces of fire apparatus now in service are past their age limit and will necessarily have to be replaced in the next few years. The rise in number of purchases in 1935 is quite noticeable and in the next few years should continue.

In the purchase of such important municipal equipment as fire apparatus it would seem that most cities would have a logical plan developed for replacement of worn-out apparatus, for funds to provide for emergencies due to the wrecking of apparatus, and funds for proper expansion with the growth of the city, with a definite annual appropriation for the fire department budget to cover these items. The reverse of this is actually the case. Very few cities have any logical plan for the replacement of worn-out fire apparatus, but have a hit or miss policy. In a good many cities it takes a bad fire to scare the people or the city officials into an appropriation for the purchase of new fire apparatus. All too often the purchase of apparatus depends upon the persuasiveness of the fire chief and his ability to compete successfully with other municipal departments for funds. In some instances a long-term unfavorable fire record will finally arouse the people to the necessity of rehabilitating the fire department. Some ten years ago Kansas City, Mo., awoke to the bad fire record which it had and the desirability of doing something about it. The city voted a large bond issue and purchased at one time some twenty pieces of new fire apparatus. Such procedure is obviously uneconomical and not to the best interest of the department. A gradual replacement program would keep the department at a reasonable level at all times instead of jumping from very poor to very good all at once. There are many cities now that have allowed their fire apparatus to become seriously inadequate because of neglect of a pro-

gram of replacement. Good examples of this are Des Moines, Cleveland, Flint, Michigan, and Springfield, Illinois, all of which are faced with the need for large expenditures for new fire apparatus because of lack of a regular replacement program.

Age of Municipal Fire Apparatus.

The N.F.P.A. field engineering service recently made an analysis of the apparatus situation in 19 typical cities ranging in population from 50,000 to 500,000. These cities had in service 229 pumping engines, 83 ladder trucks, and 63 hose wagons. Forty-three per cent of this apparatus was more than fifteen years old. Only about 10 per cent had been purchased in the last five years. About 10 per cent was more than twenty years old. Based on the recommendations of the engineers of the National Board of Fire Underwriters with respect to fire apparatus, there was a deficiency of 15 per cent in pumping capacity, 27 per cent in hose wagon capacity, and 26 per cent in ladder trucks. In none of these cities could be found any logical procedure for the replacement of old apparatus, for expansion of the department, or for building up the reserve strength of the department. All of them are faced with needlessly heavy expenditures in the next few years for additional fire equipment if the department is to function adequately.

From the above it appears obvious that altogether too little attention has been paid to the long range program of municipal fire department development and maintenance from the equipment point of view. Provision of a well-planned annual budget for fire department apparatus would not only insure the adequate functioning of the fire department but would prove of positive benefit to the taxpayers. Now as never before attention is being directed to the efficiency of municipal service departments and to sympathetic consideration of the taxpayer. More consideration to this important phase of the municipal problem of purchase of fire apparatus will prove helpful to fire departments and taxpayers alike.

Fire Extinguisher Recharging Rackets.

Incompetent and fraudulent recharging service of fire extinguishers by persons representing themselves as specializing in this work has been reported from various parts of the country within the past several months. Some reports also indicate malicious practices in connection with sales and repair services. These rackets have reached serious proportions in several cities, requiring definite action by the local fire department to control the situation and safeguard the owners of first aid fire appliances.

In the case of the soda-acid type of extinguisher abuses such as using the improper grade of sulphuric acid, soda solution being changed and the old acid being reused, and the soda or acid being left out or used in the wrong amounts, have been reported. Either one of these may render the extinguisher useless. In one instance the ring cap of a 2½-gallon soda-acid extinguisher blew off when the extinguisher was operated. An investigation revealed that the men recharging it had used a cap gasket that was too thick—allowing only two threads to hold the cap.

There are numerous cases of refilling vaporizing liquid (carbon tetrachloride base) type extinguishers with water or sub-standard liquid containing moisture and other impurities. Often the use of the wrong fluid is not made known until an attempt is made to use the extinguisher on a fire. One user reported that an electric shock had been received when using a vaporizing liquid type extinguisher on an electrical fire. An investigation disclosed that a sub-standard liquid had been used in refilling.

Apparently improper practices in connection with other types of extinguishers are not so common as with soda-acid and vaporizing liquid types. However, there are a few cases of foam type extinguishers being improperly recharged. In one instance, four 2½-gallon foam extinguishers failed to operate at the time of fire in a large automobile salesroom and repair department, where $150,000 to $200,000 worth of automobiles and trucks were on display or in storage. It was later found that the thirty odd 2½-gallon foam extinguishers at this occupancy had been improperly recharged. The person doing this work had placed the dry powder in the inner container and poured water on top of it without making any attempt to dissolve the aluminum sulphate.

The fire prevention bureaus of fire departments in Chicago, Denver, Minneapolis, and other cities have sent open letters to owners of fire extinguishers to expose the recharging racket and to give specifications for recharging the various types of extinguishers. Service men and salesmen in these cities are also generally required to obtain a certificate of approval or fitness from the

bureau to do this work. The open letter sent out by the Minneapolis Fire Prevention Bureau is a typical example. The two opening paragraphs and the closing paragraph are quoted below.

> To Whom It May Concern: It has come to the attention of this office that many fire extinguishers have been recharged in an improper manner and in the interests of all concerned, the following information is given. As an owner of first aid fire equipment, you have made an investment for protection and you are entitled to the full value and protection of the equipment concerned. The finest piece of equipment is rendered useless if it is not properly maintained and such practice as incorrect recharging can contribute to the absolute destruction of fire extinguishers.
>
> The National Board of Fire Underwriters requires that all fire extinguishers, the contents of which are expelled by self-generated pressure, shall be recharged at least once a year and immediately after each time they are used. These same requirements are also embodied in the Municipal Code of the City of Minneapolis. The foam type and the soda-acid type are the most common of the self-generated pressure types of fire extinguishers.
>
> (Recharging specifications included here)
>
> For Your Own Protection, Insist on the Following Service When Having Your Fire Extinguisher Recharged: (1) A standard prepared chemical recharge; no substitutes. (2) Extinguisher thoroughly washed and hose line flushed. (3) Service tag stating the date of recharging and the name and license number of the firm or party rendering this service to be securely attached to the extinguisher and *left there*. (4) Have service rendered by a licensed party or firm. (5) All recharging of fire extinguishers should be done on the premises. (6) Servicemen and salesmen whose workmanship and merchandise are approved will be in possession of an official certificate of approval, which is issued jointly by the Fire Prevention Bureau and all firms handling approved merchandise. When transacting business involving fire protection equipment, it is recommended that you request presentation of this identification certificate.

In Los Angeles there were found a number of cases where extinguishers were removed from the rack, a new tag attached and the extinguisher replaced on the rack without changing the solution. As a result, a city ordinance was passed requiring persons engaged in the business of recharging or refilling portable fire extinguishers to obtain a certificate of fitness from the Bureau of Fire Prevention. An applicant for a certificate must first fill out a detailed application form and furnish satisfactory proof that he is familiar with the materials used in recharging and repairing extinguishers and that he is competent to do such work.

In addition to giving specifications for recharging the different types of extinguishers, the Los Angeles ordinance states that:

> Every portable fire extinguisher required by law to be installed or maintained within the corporate limits of the City of Los Angeles shall bear the approval and label of the Underwriters' Laboratories, Inc., or a stamp of approval of any other recognized laboratory approved by the Board of Fire Commissioners.

Violation of any provision of this ordinance is a misdemeanor, punishable by a fine of $500 or 180 days in jail, or both. Since the enactment of the ordi-

nance in March of last year, frauds of this nature have been practically eliminated in Los Angeles.

(FRONT SIDE)

Certificate of Approval

FIRE EXTINGUISHERS, EQUIPMENT, RECHARGES

This is to certify that.....is approved as being competent to render fire extinguisher recharging service in a proper manner. All fire extinguishers, recharges, equipment, and component parts thereof bearing the label of Underwriters' Laboratories are likewise approved.

Approved by:

.....

Bureau of Fire Prevention—Denver Fire Department
City and County of Denver

(BACK SIDE)

No..... Date.....

Name of Bearer.....

Representing .....

This certificate subject to revocation by the Bureau of Fire Prevention at their discretion.

Form for certificate of approval used by the Denver, Colorado, Fire Department.

The licensing of extinguisher recharging service men is not necessarily the best or only solution of this problem. Much can be accomplished by the wider use by property owners of available educational literature on the maintenance of extinguishers, such as the Regulations on First Aid Fire Appliances developed by the N.F.P.A. Committee on Field Practice. The manufacturers of extinguishers, represented by the Chemical Fire Extinguisher Association (member N.F.P.A.) in coöperation with the Committee on Field Practice are now engaged in the development of ways and means for assisting property owners in steering clear of these rackets.

Wooden Shingle Roof Fire, Denver, Colo.

The fire safety of asphalt roofing as compared with the dangerous wooden shingles was perhaps never more clearly demonstrated in a single instance than that recorded by the accompanying picture. Needless to say, the house on the right of the picture had a wooden shingle roof before the fire. The house on the left still has its original composition asphalt shingle roofing. The picture was contributed by The Lehon Company of Chicago (Member N.F.P.A.) and a report of the fire was furnished through the courtesy of the Denver, Colo., fire department in which city the fire took place.

The fire occurred on the roof of the house at the right of the picture located at No. 1277 St. Paul Street, Denver, on December 5, 1934. The fire was caused by sparks from the chimney igniting the wooden shingle roof. The fire not only burned off the shingles and the roof, but also spread into the attic before it could be controlled. The house, which was valued at $4500, suffered a loss of $1295. The contents, valued at $1250, suffered $265 damage, making a total loss of $1560 for the house having the wooden shingle roof.

The house at the left of the picture, located at No. 1273 St. Paul Street, was covered with composition asphalt shingles. This house was valued at $5000 and its contents at $1000. The composition roof on this house was severely exposed to the heat and flames and the remains of large embers which fell harmlessly on the fire retardant asphalt roofing may be seen in the picture. The only damage to the fire retardant roofing was due to slight melting from the severe heat. This damage amounted to only $79.50 and no other damage resulted to the dwelling or its contents.

Explosion-Proof Electrical Equipment.

By A. H. Nuckolls,
(Member N.F.P.A.).

Many members of the National Fire Protection Association will recall that a few years ago it was the practice of inspection authorities to prohibit the use of electrical equipment having sparking or arcing contacts in locations where volatile flammable liquids or flammable gases were present. Provision was therefore made for the segregation of electrical equipment in non-hazardous areas. Such provisions, however, were not always effective, and sometimes more serious fire and explosion hazards were introduced by the substitution of objectionable methods of power application. The location of a motor outside the hazardous area and the driving of machinery by extended shafts involved the use of bearings and belts. It was impractical to make the openings for the shafts or belts gas-tight, and the additional hazards of hot bearings and static electricity were introduced. Many of these installations not only failed to provide adequate protection to life and property, but gave a false sense of security.

It is apparent, therefore, that the development of electric motors and other electrical equipment for use in hazardous locations is an outstanding advance in fire and explosion prevention. Today explosion-proof electrical equipment for various uses is available which not only meets the exacting requirements of safety, but which is efficient and obtainable at a reasonable cost.

Before discussing the principles of construction of the explosion-proof type of electrical equipment and some of the latest developments in this field, it will be of interest to give brief consideration to the meaning of "Class I locations," in which explosion-proof equipment is designed for use.

Class I Locations.

It is the function of Article 32 of the National Electrical Code to define and classify hazardous locations in order that the inspection authority enforcing the code may judge as to the need of explosion-proof equipment in any area. Briefly stated, the provisions of this article apply to locations in which there is danger of the atmosphere containing flammable vapor or gas. The deciding question, therefore, in any case is whether or not flammable vapor or

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This article was presented as a paper at the 40th Annual Meeting of the National Fire Protection Association at Atlantic City, May 11-14, 1936. For discussion see Proceedings (printed as Part 2 of this QUARTERLY), page 287. Mr. Nuckolls is Chemical Engineer of Underwriters' Laboratories, Chicago, Chairman of the N.F.P.A. Committee on Hazardous Chemicals and Explosives and a member of various other N.F.P.A. technical committees.

gas is present, or likely to be present, in any given area in dangerous quantity. It is important to understand just what is meant by "gas or vapor in dangerous quantity." It is clear that when the quantity or concentration of the gas or vapor is high enough to propagate flame if ignited, there is danger. Some vapors or gases propagate flame more rapidly, one may say more violently, than others, and evidently the degree of danger will depend upon the nature of the gas or vapor as well as its concentration and the surroundings. Flammable gases or vapors, therefore, have been subdivided into groups designated "A," "B," "C," and "D," as will be discussed later.

Explosion-proof Type of Construction.

Coming now to the principles of construction of the explosion-proof type of electrical equipment, for convenience it is desirable to refer, particularly in this discussion, to the type of construction employed for motors of the explosion-proof type, as it would require too much time to cover in detail all the types of explosion-proof electrical equipment in use. The essential feature in the construction of all explosion-proof equipment is the enclosure, as will be seen later. In general, the principles employed in the design and construction of enclosures for explosion-proof motors apply to the enclosures of other forms of explosion-proof equipment.

It is clear that the ordinary type of electrical motor is of a form of construction that permits the surrounding atmosphere to pass or diffuse into the interior, and consequently if a flammable vapor or gas is present, it may be ignited by a spark from the moving contacts, or from short circuit caused by injured or defective insulation, or by high temperatures from a burn-out.

In designing a motor for use in Class I locations, the most obvious method, therefore, would be to employ a gas-tight enclosure to prevent the entrance of flammable vapor or gas, thus removing the danger of internal ignition from sparking contacts or arcs. Although it is practicable to construct enclosures for motors which prevent the entrance of appreciable quantities of dust, the only way to insure the exclusion of gases or vapors is to permanently seal the enclosure, which is impractical. Even if hermetically sealed when new, the enclosure would not remain gas-tight under service conditions. In practice, attempts to make enclosures for motors or other electrical equipment gas-tight, by the use of gasket materials such as rubber, have failed to remove the danger, and in the interests of safety should be entirely avoided.

Since it is impractical to construct gas-tight enclosures for motors and other electrical equipment, it is necessary to so construct the enclosure that if gas or vapor within it is ignited the resulting flame* is prevented from

*NOTE: It is recognized that in addition to flame, sparks and gases at high temperatures are capable of causing ignition. The forms of construction required have been found by actual explosion tests described later to be capable of preventing the ignition of surrounding flammable atmospheres by both sparks and hot gases (products of combustion) as well as by flame.

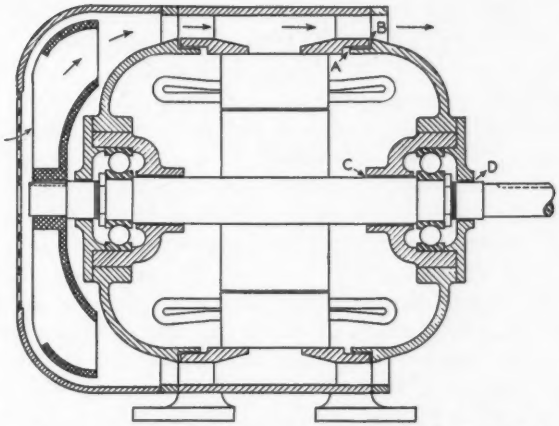


Fig. 1. Cross section of openings in a modern type of fan-cooled explosion-proof motor.

propagating to the outside surrounding atmosphere. This is a fundamental requirement for motors and other electrical equipment of the explosion-proof type. The design of equipment to meet this requirement is based on the principle that the propagation of flame through an opening is prevented when the dimensions of the opening are within certain narrow limits. It is not surprising, therefore, that considerable effort has been devoted by manufacturers to the design of the details of openings in enclosures for explosion-proof equipment.

OPENINGS IN THE ENCLOSURE. Fig. 1 shows in section the openings in a modern type of fan-cooled explosion-proof motor. A type of end shield joint is shown at A-B. A form of shaft opening in the enclosure is shown at C-D. For convenience, the distance A-B is termed the "flame path." The unoccupied space in the enclosure is known as the "free space" or "free volume."

Suppose that a motor of this type is surrounded by a flammable vapor or gas. The vapor or gas diffuses through the openings or clearances, filling the free space. Assume now ignition of the vapor or gas in the enclosure occurs. Naturally the flame spreads, and pressure is produced within the enclosure by the expansion of gaseous products of combustion caused by the heat of the reaction. If the length of the path at the joints is long enough and the clearance is small enough, the flame propagation will be arrested between A and B, thus preventing ignition of the surrounding atmosphere. In general, within certain narrow limits, the less the clearance, the less the length of path required to arrest the propagation of flame. No fundamental or mathematical formula has been established for this relationship. Much depends upon the nature of the gas or vapor and the type of opening.

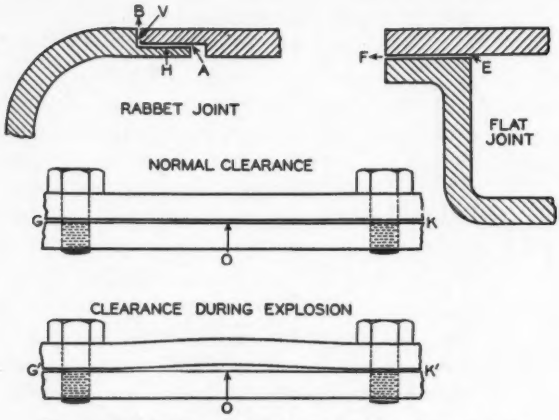


Fig. 2. Explosion-proof flat and rabbet types of joints.

The types of openings shown at the end shield joints A-B are typical forms of rabbet joints.

Fig. 2 gives in some detail a rabbet joint and also shows a flat joint. The rabbet joint is much more effective than the flat joint in arresting flame, other factors assumed to be equal. An even more effective type of joint for arresting propagation of flame is a threaded joint, five full threads being an excellent type of flame arrester.

It is important to note that the clearance at an explosion-proof joint is increased more or less during the explosion by the pressure effect. This is illustrated in Fig. 2 at O. This increase in clearance depends upon the explosion pressure, the strength of the enclosure, and the bolt spacing. A number of failures in explosion tests on account of the increase in openings at joints have occurred with equipment otherwise meeting rigid specifications as to dimensions of joints.

STRENGTH OF ENCLOSURE. It is also important that the enclosure itself shall be of substantial construction in order to meet service requirements and have sufficient strength to withstand without appreciable distortion or rupture the maximum internal pressures that may be developed by an explosion.

BOLTS AND BOLT HOLES. It is evident that the bolts employed for the assembly of the enclosure should be of adequate strength and so spaced as to prevent a dangerous increase in clearance between parts during an explosion. Holes for name plates and for securing the mechanism must be closed or bottomed. The omission of a bolt at the joints, irrespective of whether the bolt hole is bottomed, is liable to permit a dangerous increase in the clearance during an explosion.

LEADS. The leads or conductors must be tightly fitted or sealed and

securely held in place where they pass into the enclosure.

FREE VOLUME OF ENCLOSURE. The unoccupied space or free volume of an enclosure is another important factor in the design of an explosion-proof enclosure. The explosion pressure of a vapor or gas, within certain limits, will depend largely on the amount of free volume. If the free volume is extremely large, a pressure wave known as "detonation" may develop. It is hardly practical to construct electrical enclosures to withstand detonations, but it is practical to make enclosures having free volume small enough to avoid the danger of detonations in the case of the most common gases.

SHAPE OF ENCLOSURE. It is of great importance in the design of enclosures to avoid forms of construction that divide the free volume into communicating compartments, which may permit abnormally high explosion pressure effects known as "pressure piling." An explosion beginning in one compartment of the enclosure may cause compression and turbulence of the gaseous mixture in another compartment in advance of the flame. Further, the advancing flame front from one compartment may ignite the already turbulent and more or less compressed mixture in the other compartment simultaneously at a large number of points.

Electrical Requirements.

Space does not permit a discussion of the electrical requirements, but in passing it may be mentioned that it is particularly important in the design of explosion-proof equipment to have the spacing between parts of opposite polarity and of live parts and enclosure adequate. The spacing of live parts that is adequate for air-filled enclosures may not be sufficient in the case of an enclosure filled with burning gas, because flame is accompanied by ionization, with consequent increase in electrical conductivity.

Motors are subject to burn-out, and it is required, therefore, that motors of the explosion-proof type be of such form of construction that if a burn-out occurs the enclosure does not reach a dangerous temperature.

Class I Locations Divided Into Four Hazard Groups.

There is a wide difference in the explosive properties of many vapors and gases, particularly as to the rate of flame propagation and maximum explosion pressure. It will be noted from Fig. 3, which shows the explosion pressure curves for mixtures of acetylene, propane, and ammonia, respectively, with air, that the maximum explosion pressure of acetylene is much higher than that of ammonia or propane. It will be clear, therefore, that a motor casing or enclosure of sufficient strength for propane would not necessarily be safe for use with acetylene.

It may then be asked, "Why not design a motor or other electrical equipment for use with the most explosive gas met with in practice?" Like many theories, this one cannot be satisfactorily applied in practice, particularly from an economical standpoint. For example, a motor constructed for safe use in

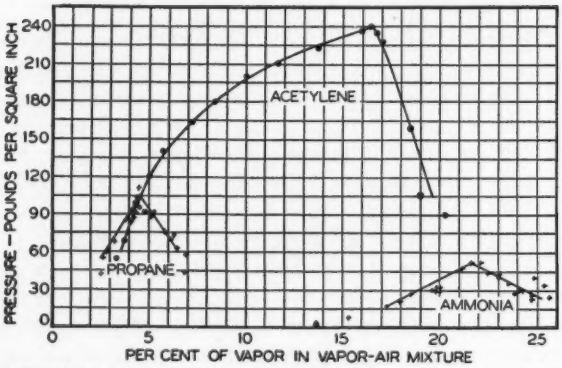


Fig. 3. Explosion pressure curves of acetylene, propane, and ammonia in air.

acetylene gas would be far more expensive and massive in construction than a motor suitable for use in gasoline vapor.

As the differences in explosive effects of many of the common gases and vapors are sufficient to call for different forms of construction of explosion-proof electrical equipment, common gases and vapors met with in Class I locations have been divided into groups as previously mentioned.

Group A is the most hazardous of the groups, and is represented by acetylene.

Group B refers to atmospheres containing hydrogen, or gases or vapors of similar hazards, such as manufactured gas (illuminating gas).

Group C refers to atmospheres containing ethyl ether vapor, or gases or vapors of equivalent hazard.

Group D, which is the most common group, refers to atmospheres containing vapors of gasoline, or vapors or gases of equivalent hazard, such as petroleum, naphtha, lacquer solvents, and natural gas (methane).

Explosion Tests.

It is clear from the foregoing that it would be difficult to cover adequately in a standard all details of the various features of construction on which the safety of explosion-proof equipment depends. Such a standard would permit little, if any, leeway in the design of explosion-proof equipment, and would hamper progress in manufacture.

The explosion tests serve as a final criterion for acceptance or rejection of the electrical equipment submitted to Underwriters' Laboratories. It is clearly of the highest importance that the test procedure employed be practical in its application and fully dependable. It must therefore be based upon the fundamental principles of flame propagation. These principles, which will now be discussed briefly, relate primarily to the development of the explosion pressure and the propagation of flame through openings in an enclosure.

CONCENTRATION FOR MAXIMUM PRESSURE. It has been shown that there is wide difference between the explosion pressures of many vapors and gases. It is to be noted further that all explosions of the same gas or vapor are not necessarily alike. Explosions of acetylene, for example, may be weak, developing little pressure, or violent, developing a high pressure.

By referring again to Fig. 3, it will be seen that the explosion pressure of any of the vapors and gases included depends upon their concentration in air. For example, a low percentage of acetylene or of propane in air gives a low explosion pressure. A very high percentage of acetylene or propane may also give a low pressure. It will be noted, further, that the percentage of acetylene (its concentration in air) which gives a peak explosion pressure is different from the concentration of propane or of ammonia which gives a peak pressure. Fig. 4 shows the explosion pressure curve of gasoline. It will be noted that the concentration or per cent of gasoline vapor in air which yields maximum pressure is approximately 2.2. It will be evident, therefore, that the control of the test concentrations in explosion tests is of primary importance. Before discussing our method of control it will be of interest to note the effects of turbulence, and the intensity and location of the source of ignition.

TURBULENCE. The explosion pressure curves shown are based upon quiescent mixtures, and while they illustrate the importance of the relation between the pressure effect and the concentration of gas or vapor, they do not record the highest explosion pressure obtainable under all conditions with the gases included. If the explosive mixture is in a state of mechanical agitation or turbulence at the time of ignition, a higher explosion pressure is developed. Some forms of explosion-proof electrical equipment, such as motors, when in operation, cause a marked turbulence of a gas within the enclosure, and it is important, therefore, to have such equipment in operation during some of the explosion tests.

INTENSITY AND LOCATION OF SOURCE OF IGNITION. The intensity and location of the source of ignition also influence flame propagation within an enclosure. Having a point of ignition near a flame path at a joint or other opening causes the flame to propagate more readily to the outside. In many of the explosion tests the use of a spark plug properly located for effective ignition inside the enclosure has the advantage of saving much time. In the case of some types of explosion-proof equipment, such as circuit breakers, which may yield intense arcs, it is necessary in order to duplicate operating conditions to depend upon the device itself for ignition of the explosive mixture. Judgment is required in choosing the method of ignition to be employed in order to obtain the element of danger to be anticipated under service conditions.

FLAMES DIFFICULT TO ARREST. The concentration of gas or vapor in air which gives the maximum explosion pressure does not necessarily produce the

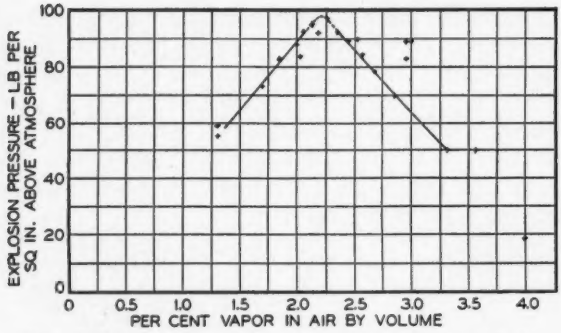


Fig. 4. Explosion pressure curves of gasoline vapor in air.

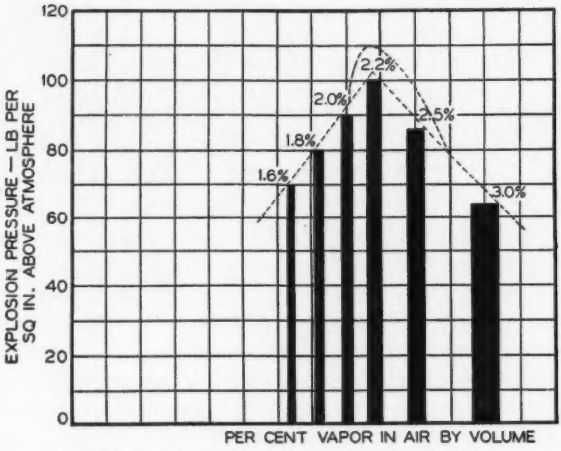


Fig. 5. Diagram of gasoline vapor-air explosions.

flame which is most difficult to arrest at openings in the enclosure. In other words, it would not be sufficient for the purpose to test an enclosure only with the mixture or concentration of vapor in air giving the highest explosion pressure. It has been found that mixtures containing approximately 1.8 per cent by volume of gasoline vapor in air are much more likely to produce discharge of flame at the joints or other openings than mixtures of the order of 2.2 per cent by volume.

Before data now available on the different explosions that may be produced by gasoline vapor in air were obtained, it was necessary to include a large number of explosion tests in order to be certain that the explosive range was fully covered.

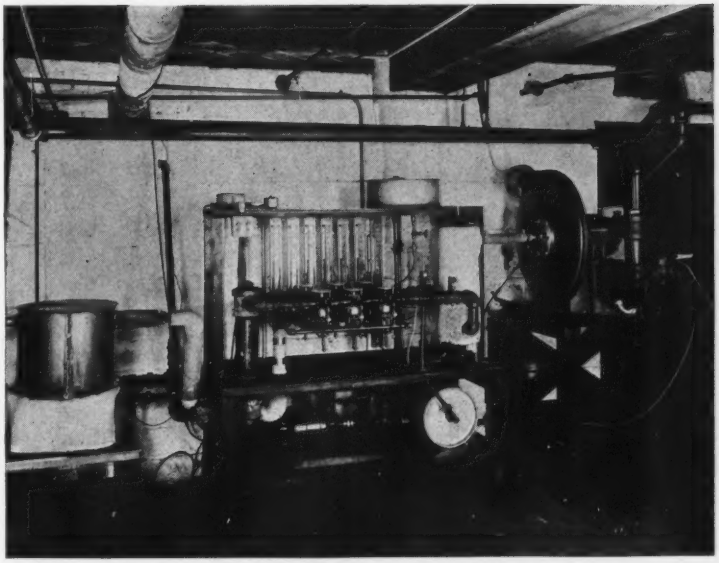


Fig. 6. Carburetor for use in explosion tests.

It is possible to duplicate under the test conditions now employed any of the more dangerous explosions that may be produced by gasoline vapor. In the chart, Fig. 5, the column marked "2.2 per cent" represents an explosion giving the maximum pressure, while the column marked "1.8 per cent" represents an explosion giving less pressure but giving a flame which is more difficult to arrest than the flame of the explosion represented by the column "2.2 per cent." The width of the columns represents roughly the duration of the flame during the kinds of explosions shown. The main dotted line represents the explosion pressure curve for gasoline (see Fig. 4).

CONTROL OF TEST CONCENTRATIONS. In order to obtain the necessary control of the concentrations of vapor and air for the explosion tests without undue expenditure of time, it is necessary to employ special equipment, the development of which required a number of years of experimental work. The amount of time saved by such equipment appears to have justified the labor involved in its development, and it is with some degree of satisfaction that Fig. 6, a photograph of the apparatus called "the carburetor," is shown. With this apparatus and accumulated data as to the effects of the various explosion mixtures in terms of pressure as well as in terms of flame propagation at joints, it has been possible to limit the number of explosion tests necessary to determine whether a given electrical apparatus could be expected to function safely in an explosive atmosphere.

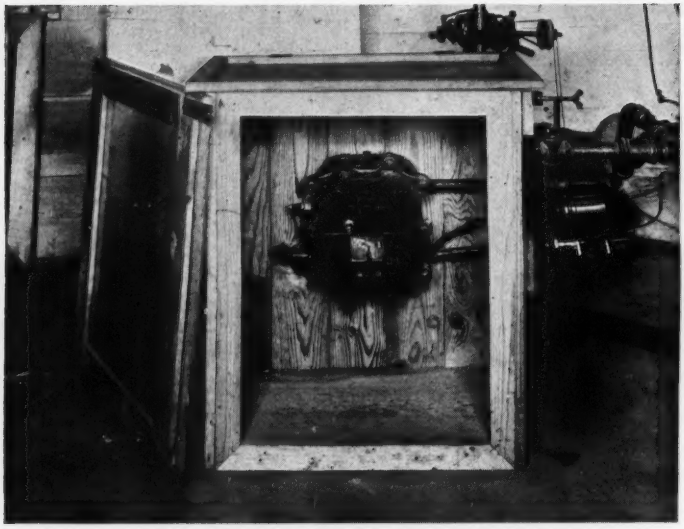


Fig. 7. An actual explosion test installation.

OTHER TEST CONDITIONS. Finally, it is essential that the conditions of the explosion tests be comparable with dangerous conditions as met with in practice. To accomplish this, the motor or other electrical equipment for test is tapped with threaded holes for attachment of a spark plug, a time pressure recording device and pipe connection to the carburetor, and installed in an explosion box, which is also connected to the carburetor. Outlet connections are provided for the electrical enclosure and the explosion box in order to permit the displacement of the original air in both by the explosive mixture of gas or vapor.

Figure 7 is a photograph of an actual test installation which is connected to the power line. The front of the explosion box, which contains the explosive mixture surrounding the electrical enclosure, is made of readily replaceable transparent material to enable an observer, protected by sand bags, to note, first, whether an explosion in the electrical enclosure causes ignition of the surrounding explosive mixture in the box; and second, in case ignition of the surrounding mixture does not occur, whether dangerous sparks or flame are discharged from any of the openings of the electrical enclosure.

If the surrounding mixture in the box is ignited, the electrical equipment has failed to meet the test. If the surrounding mixture is not ignited, but the visible discharge of dangerous sparks or flame from the openings in the enclosure occurs, it is safe to conclude that the danger of failure has been reduced, but that the margin of safety provided, if any, is inadequate. A

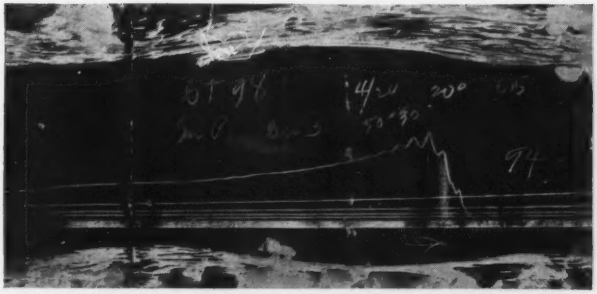


Fig. 8. A typical time-pressure record of an explosion test.

typical time-pressure record of such a test is shown in Fig. 8.

Machinery in general, and particularly when equipped with safety devices to prevent accidents to workmen, requires more or less supervision. Likewise, electrical equipment for use in hazardous locations requires reasonable supervision to safeguard against its improper use, which might result in serious losses or accidents. While the design and test performance required by Underwriters' Laboratories standards call for forms of construction which are as nearly foolproof as practical to manufacture, reasonable care in installation and maintenance must be assumed.

The importance of providing electrical equipment for safe use in explosive atmospheres need not be dwelt upon. Loss of human life, as well as loss of property by fire and explosion, is involved, which fully warrants the added expense incident to the installation and maintenance of explosion-proof equipment in locations where dangerous atmospheres are likely to exist.

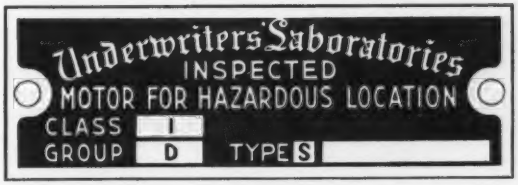


Fig. 9. Label for explosion-proof motor.

Mishaps With Oil-Filled Transformers.

By M. G. Lloyd (Member N.F.P.A.),
National Bureau of Standards, Washington, D. C.

The alternating-current system of distribution of electric energy is nearly universal in this country, and the transformer as a device for stepping up and stepping down voltage is one of the most commonly used pieces of electric apparatus. While different types of transformers have been developed and have used different media for insulation and cooling, the oil-filled transformer is the most usual type and is supreme, especially in the field of the step-down distribution transformer.

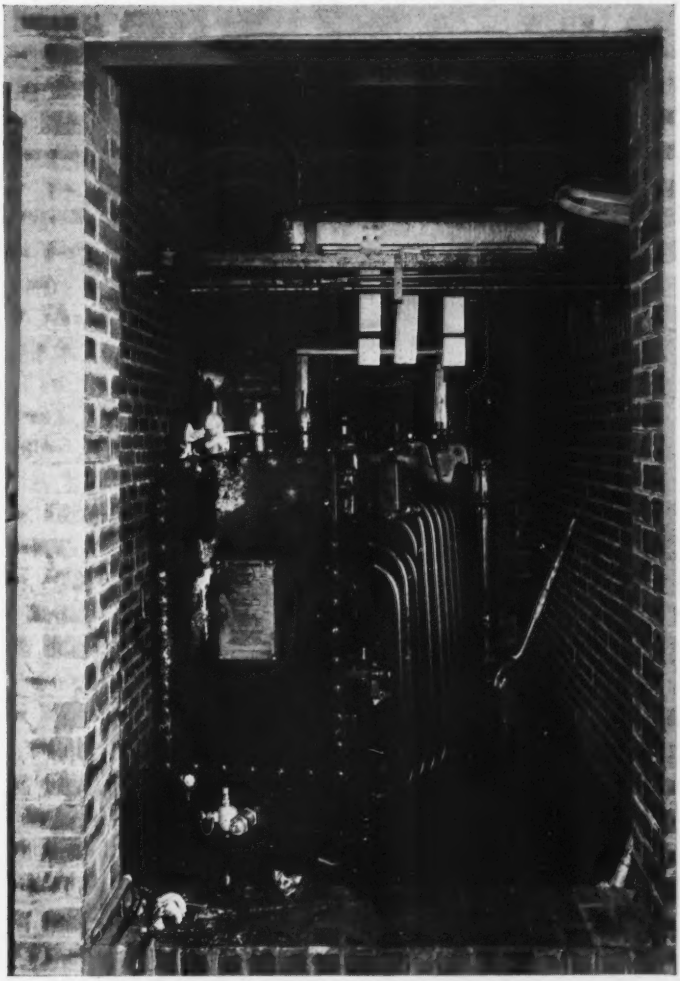
In view of the very extensive use of this type of transformer, involving as it does the hazard of a highly flammable liquid, its record is remarkably good and its failures have been very largely due to outside causes, such as lightning or excessive overloads, rather than to any internal failure. A recital of certain instances of trouble occurring in connection with this type of transformer is, on that account, of particular interest as showing the existence of possible weaknesses in present methods and as pointing the way to possible improvements in the future.

Article 11 of the National Electrical Code contains regulations governing the installation of transformers of all types, and Article 50 contains additional rules for transformers used on circuits of more than 600 volts. Among the requirements for oil-filled transformers is one which requires such a transformer, if inside of a building, to be installed in a vault, and somewhat detailed specifications for the construction of such a vault are included.

Loew's Theatre, Providence, R. I., July 20, 1928.

This was a 3-phase, oil-filled, 450-kva transformer with primary connected to a 11,000-volt feeder, and the secondary connected to a 4-wire network operating at 208/120 volts. The high-tension terminals passed through bushings into a separate compartment of the tank which contained a 3-pole, manually operated disconnecting switch which was electrically interlocked so that it could not be opened when the transformer was energized. This switch connected the primary coils to a feeder running to a substation, where it was controlled by an automatic oil circuit-breaker. The secondary windings of the transformer were connected to a secondary network through network protectors intended to automatically open the secondary circuit if current should feed back from the network to the secondary winding.

This article was presented as a paper at the 40th Annual Meeting of the National Fire Protection Association, Atlantic City, May 11-14, 1936. For discussion see Proceedings (printed as Part 2 of this QUARTERLY), page 141.



Interior of the transformer vault after the transformer exploded in the basement of the office building of the Potomac Electric Power Company, Washington, D. C., on June 29, 1935. This explosion, which ripped open the case and shot out burning oil, was caused by a short-circuit when two workmen were installing a thermometer in the case. The stream of burning oil burned to death the two workmen, a foreman who went to aid them, and two carpenters 20 feet away.

This transformer and a duplicate one were installed in a vault of standard type in the basement of the theatre.

On the day of the explosion one of the transformers was being put into service for temporary use by the building contractor. For this purpose the circuit-breaker was closed on the feeder at the substation, and about five minutes later the compartment of the transformer which contained the grounding switch exploded and scattered burning oil around the vault and through the open door of the vault to the neighboring space. Four men in the vault and two who were outside were burned by the oil, the burning being fatal to two of them.

Apparently the development of sufficient heat in the switch compartment to cause the explosion was due to the grounding switch having been left closed at the time the feeder was energized at the substation. The switch compartment contained about 25 gallons of oil, which was scattered in a burning condition, but the remainder of the transformer was uninjured. The fire was easily extinguished after the circuit-breaker at the substation opened on account of the short-circuit existing on the feeder.

Office Building, Potomac Electric Power Co., Washington, June 29, 1935.

This was a 3-phase, oil-filled, 300-kva transformer; the case was 3 ft. by 6 ft. by 5 ft. high and contained about 152 gallons of oil. The bottom was welded to the sides, whereas the top was bolted on. The transformer stepped the voltage down from 13,750 volts to 115-230 volts.

This transformer was located in a vault in the basement of an office building and was adjacent to space used for automobile storage. There were three transformers in the vault, with barriers between the transformers. These barriers did not reach to the ceiling, nor to the back wall. There was a door in front of each transformer, with a 14-in. sill which was also extended below the barriers between transformers.

Thermometer, tube and fitting. Points of contact where tube caused short circuit may be noted.

The transformer had a metal thermometer tube inserted through a hole drilled in the case of the transformer. This thermometer registered on an exterior dial and included a relay for control of a fan motor for air cooling. The wires of this circuit were brought to the indicating gauge, which was attached to the transformer case by a threaded pipe.

The installation was new and the transformer was about ready for service, but up to the time of this accident carried no load, although the high-tension terminals were connected to the feeder cable from the substation.

On the morning of the accident two men were working in the transformer vault, with the door opposite the transformer standing open. In connecting up the relay circuit the metal thermometer had been removed and was being inserted through the hole in the case when it made contact with one of the high-voltage terminals of the transformer. As the thermometer was also in contact with the case, this produced a short-circuit which immediately vaporized a quantity of oil, and the pressure produced inside of the transformer was sufficient to bulge the side

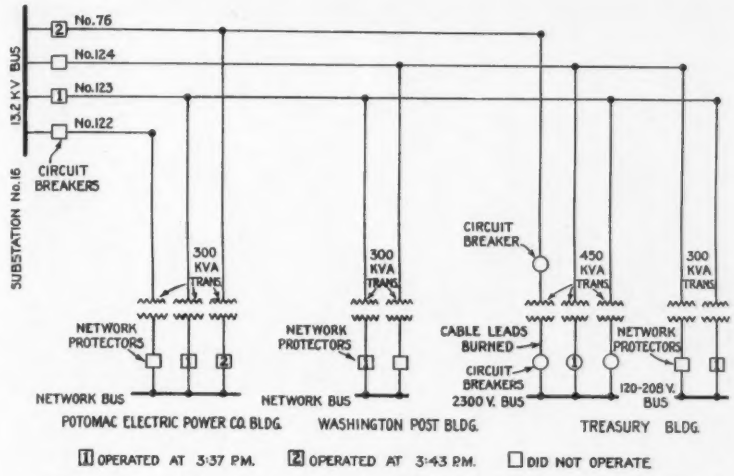


Diagram of feeders and transformers affected by the transformer failure in the Washington Post Building, Washington, D. C., on August 13, 1935.

and rip open the joint between the base and side on one side of the transformer for nearly its entire length. Expulsion of oil through this opening lifted the transformer slightly from its support.

Through the thermometer orifice there was projected a stream of burning oil, which may have been partly liquid and partly vapor and which carried an intense flame. This burned the two men in the vault and a foreman, who entered the vault to aid the men, so severely that they were killed. Moreover, the flame was projected through the doorway of the vault and burned two carpenters at a distance of 20 ft. so severely that they died.

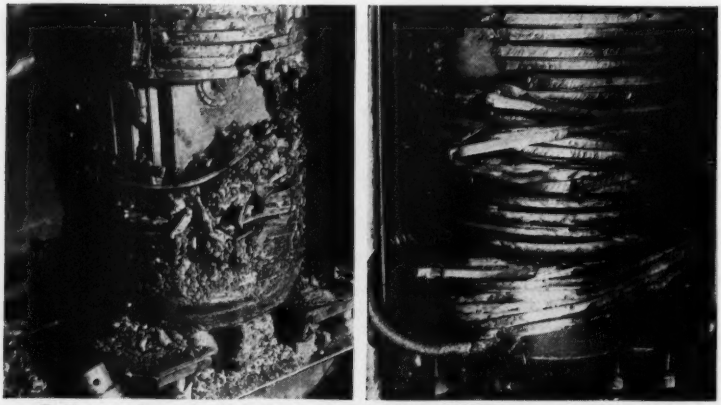
The feeder which supplied this transformer was connected to a circuit-breaker at the substation end. This breaker was set to operate in 45 cycles, or 3/4 second, on overcurrent and/or current to ground. It had a rupturing capacity of 500,000 kva and appeared to have opened in the time stated. It has been estimated that the energy which was poured into the transformer during this interval was not more than 50 kilowatt hours. This is sufficient to convert about 2.3 cu. ft. of water into steam at a pressure of 250 lbs. per sq. in.

After the opening of the supply circuit, the burning oil was extinguished without difficulty.

Washington Post Building, Washington, D. C., August 13, 1935.

This was a 3-phase, oil-filled, subway type transformer, rated at 300 kva, and stepped voltage down from 13,750 volts to 208 volts. The bottom of the transformer tank was welded to the sides, whereas the top was bolted.

This transformer was installed in a vault 18 ft. by 5 ft. 6 in. by 8 ft. 3 in. high, which had been constructed under the sidewalk. The walls of the vault were reinforced concrete 6 in. thick. The ceiling of the vault consisted of slabs of concrete in channel-iron frame except for two vents each 2 ft. 11 in. square, which were covered by gratings. These gratings were in halves and



Both secondary (left) and primary (right) windings were destroyed when a short-circuit developed in the secondary winding of Washington Post Building transformer.

were hinged on each side to the iron framework. A duplicate transformer supplied by a separate feeder was at the same location.

The transformer in question was one of a large number whose secondaries were connected to a network system, and the same feeders which supplied the transformers at this location also supplied other transformers connected to the network system, as well as some transformers whose secondaries were not connected to the network. The latter were transformers belonging to the Federal Government. In the Treasury Building there were transformers stepping down to 2300 volts, which were supplied by three feeders, one of which was the same feeder serving the transformer which failed, namely, No. 123.

Each feeder was connected at the substation through a circuit-breaker set to open in 45 cycles, or three-quarters of a second, on overcurrent or ground current. Each transformer secondary which was connected to the network was connected through a network protector which would be opened by a reverse-current relay whenever energy was fed back to the transformer from the network.

On the day of the accident it appeared that a short-circuit developed in the secondary winding of the transformer, the resulting arc communicating this fault to other windings and through a barrier which separated the primary and secondary coils. This resulted in a short-circuit from the high-tension winding to the core, and the continued arcing eventually resulted in a short-circuit between phase terminals and ground.

When the pressure, developed within the transformer case, had risen sufficiently, the top cover of the case was blown loose on one side through failure of the bolts, and the case was also slightly bulged. This released the oil and vapor and constituted the primary explosion, which caused flames to be projected through the vents to a height of 12 ft.; the rush of vapor through the gratings was sufficient to blow them from their hinges to a considerable height. A second explosion was noted some minutes later.

In this case the opening of the circuit-breaker on the feeder supplying the

faulty transformer was not sufficient to interrupt the flow of energy into the vault.

Although this feeder, No. 123, was disconnected at the substation, it was not de-energized, but was fed through a transformer at the Treasury Department. Three transformers at the latter location were supplied by three different feeders, Nos. 76, 123, and 124, and their secondaries were all connected to the same 2300-volt bus through oil circuit-breakers having overload and reverse-current trips. When feeder No. 123 was disconnected at the substation, the reverse current flowing into the corresponding transformer secondary at the Treasury should have actuated a circuit-breaker to disconnect this feeder, but this circuit-breaker failed to function.

Supply through feeder No. 76 kept the 2300-volt bus at the Treasury energized and the second transformer fed back to feeder No. 123 and thus to all transformer primaries connected to this feeder, including the faulty transformer. This overloaded the Treasury transformer, and after six minutes the overheated circuit-breaker broke down, and the resulting short-circuit actuated the circuit-breaker on feeder No. 76 at the substation, thus finally interrupting supply to the Treasury bus and also to the faulty transformer.

A small flame was visible for some time along the opening between the lifted tank cover and tank, resulting from burning of the oil vapor as it came in contact with the air. This was readily extinguished by filling the vault with carbon dioxide gas. The only person injured was a woman who was passing over the sidewalk vents at the time of the explosion. This woman was burned by the flame.

Aluminum Co. of America Plant, Alcoa, Tenn., Sept. 26, 1935.

This transformer is one of a number stepping down from 13,200 volts to about 380 volts to supply a rotary converter. The transformer was mounted outside and close to the wall of the building containing the rotary converter station of the company.

A short-circuit developed in the transformer. The oil was vaporized and sufficient pressure developed to blow off the cover by stripping the threads from two of the bolts holding it in place. Several hundred gallons of oil were blown out and ignited.

The power was cut off and the oil burned itself out, fusing metal on the exterior of the building and cracking the glass of neighboring windows. The fire entered the building through the opening thus caused and destroyed the cables and instrument transformers of one of the rotary converters.

131 East 88th Street, N. Y. City, Dec. 19, 1935.

This was a 3-phase, oil-filled, self-cooled transformer, rated 150 kva, and built about 1928. It contained about 200 gallons of oil. It was installed on a network system stepping down from 13,200 volts to 216-125 volts. It was installed in a vault about 10 ft. 6 in. by 4 ft. 6 in. by 7 ft. 6 in. high. The walls were of steel and concrete 4 in. thick. A separate compartment containing a network protector increased the length of the vault 2 ft. 6 in. The vault was ventilated by openings at the top and bottom of side walls, the latter being provided with louvers and the former with drop dampers. In addition a sheet-metal duct 9 in. by 30 in. and about 15 ft. long terminated in the building wall at the street level and supplied direct ventilation. This vault was built in a meter room about 19 ft. by 21 ft., having a brick wall 4 in. thick.

Results of a transformer explosion at 131 East 88th St., New York City, December 19, 1935. At the left is the bulged wall of the vault, and the network protector in a separate compartment. At the right is the wall of the meter room, parts of which were blown down.

Apparently a fault developed in the insulation of the secondary coil on one phase which led to a short-circuit between turns, and a resulting arc spread the damage so as to involve additional turns and the iron core. This arc apparently generated gas and carbon, and the gas seeped out around the gaskets of the loose-fitting cover. No ground developed immediately, however, because, although laminations of the core were involved, they were coated with a varnish which supplied sufficient insulation for the low voltage of the secondary winding. The pressboard insulation between the secondary windings and the core was burnt through and that between secondary and primary was partially burned, but not so as to affect the primary winding. The secondary windings were insulated with a double cotton covering.

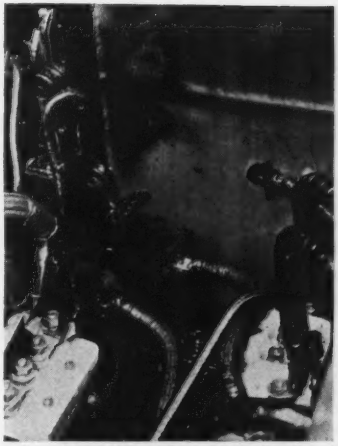
Mounted in the transformer case was a ground switch whose position was approximately directly over the faulty coil. Apparently the carbonized oil and gas lowered the insulation of the switch and finally resulted in a flashover at the ground switch between primary phases and to ground. The terminals of this switch were afterward found to be badly burned; one lead had come loose and was welded to the case.

This flashover was apparently sufficient to ignite the gas which had been developed and which had overflowed into the surrounding room. It has been computed that 0.68 to 4.8 gallons of oil, when decomposed, would supply enough oil gas to fill the vault and meter room with an explosive mixture, and that the energy necessary for this would be from 16 to 121 kilowatt-hours (corresponding to at least 1000 amperes at secondary voltage for nine minutes).

The explosion in the vault and meter room blew down the brick wall and set fire to objects in the adjacent storage space. The fire was extinguished without difficulty and no one was injured by the explosion. The vault walls on both sides were forced outward. There was no general interruption to service.

This transformer had been out of service for a day prior to the explosion, and had been in service only nine minutes when the explosion occurred.

The short-circuit to ground which accompanied the flashover and explosion resulted in disconnecting the feeder and clearing the transformer from the network.



Interior of transformer tank, showing grounding switch with burned contacts and one lead welded to wall of tank.

Conclusions.

Consideration of the cases briefly described above seems to warrant the following conclusions:

1. The need for an enclosing vault for oil-filled transformers located in buildings is definitely demonstrated.

2. The thickness of walls which is specified in the National Electrical Code appears to be justified.

3. It is well to keep transformer installations well away from gas mains, meters, and appliances, and, if outdoors, from buildings.

4. It would be advantageous to provide the transformer tank with a pressure-relief valve at the top so that the case would not be likely to burst and release large quantities of liquid oil.

5. Although the record of oil-filled transformers on the whole is not at all bad, it would be an added advantage to eliminate the use of a flammable liquid.

6. The mere provision of a transformer vault obviously does not of itself provide complete protection to either the contents or the occupants of the building in which it is located.

7. The control of the transformer vault by a public utility company does not give complete assurance of safety to the building, its contents, or its occupants, and hence there does not seem sufficient justification for exempting such installations from the usual requirements simply because they are under the control of a public utility company.

Safeguarding Industrial Ovens.

By A. L. Cobb (Member N.F.P.A.).

During the last eight or ten years the Factory Mutual Laboratories have been actively interested in the development of safeguards to prevent explosions in gas and oil-fired industrial ovens or to reduce the damage if an explosion should occur. Much of this work has involved the development of automatic equipment because dependence upon the human element alone has in many cases led to accidents. While a careful operator is perhaps the best safeguard, there is always a chance that a substitute operator may get into trouble, or that the regular operator in a careless moment may do something which will result in serious damage.

Automatic safeguards are intended to supplement careful operation and to assist the operator in correct and safe operation of the equipment. Safety controls can almost always be arranged so that they will not produce any operating hardship. In many cases the controls actually make the operator's work easier, so that he is not tempted to tamper with them.

To minimize damage to an oven if an explosion should occur, it is advisable to provide large lightweight explosion vents which will promptly relieve internal pressure. For gas-fired equipment a venting area of about 1 sq. ft. to each 15 cu. ft. of oven volume is needed. It is not always possible to arrange such vents, particularly on bakery and heat treating ovens of masonry construction. On ovens of light construction, such as the sheet metal and mineral wool insulated ovens, commonly used for japan baking, it is possible to arrange effective explosion vents by leaving the roof unfastened, or by providing venting panels in the walls.

Often the cheapest and simplest venting arrangement is to make use of the regular oven doors, providing latches which will release when an internal explosion occurs and allow the doors to open. Fig. 1 shows a number of latches which are commercially available or can be made by mill mechanics. Latches should be so arranged that a man can readily push the door open. If this simple test is applied, the doors will act readily in event of explosion.

Probably the most important factor in the prevention of explosion in japan ovens, or other drying processes where flammable vapors are present, is the maintenance of adequate ventilation. After an estimate is made of the

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Mr. Cobb presented this paper at the 40th Annual Meeting of the National Fire Protection Association, Atlantic City, N. J., May 11-14, 1936, at which time he was connected with the Factory Mutual Laboratories, Boston, Mass. Mr. Cobb is now Safety Engineer for the Eastman Kodak Company, Rochester, N. Y. For discussion see Proceedings (printed as Part 2 of the QUARTERLY), page 288.

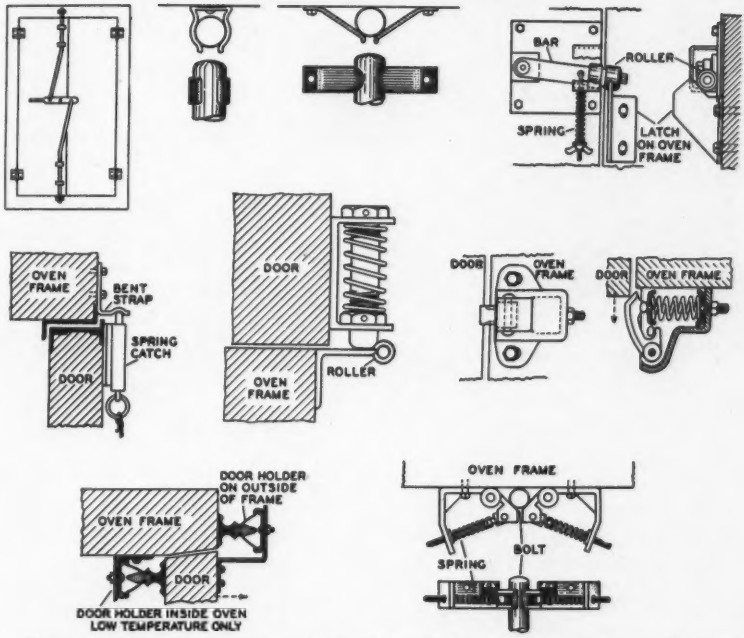


Fig. 1. Friction and spring types of oven door latches which will release the doors readily when pressure develops in the oven.

quantity of solvent evaporated in the oven, the amount of ventilation needed to prevent the formation of an explosive vapor-air mixture in the oven can be calculated, and enough additional ventilation provided to assure an adequate margin of safety. The total ventilation required is about 350 cu. ft. of air (calculated at 70° F.) per minute for every gallon of solvent evaporated in each oven charge for a box-type oven. For conveyor ovens it is not safe to allow less than 9000 cu. ft. of air at 70° F. for each gallon of solvent evaporated. This makes suitable allowance for an uneven rate of evaporation. This ventilation should be provided by fans or blowers. Interlocking devices prevent the operation of the ovens unless exhaust fans are operating.

One device used is the air flow switch shown in Fig. 2, which interrupts the circuit controlling burner equipment or electric heaters (and, in some cases, the conveyor in an oven) if the exhaust fan should stop or if dampers should close, thus restricting the ventilation. Where the fan is direct-driven it is sometimes possible to supply the safety control circuit from the ventilating fan motor terminals as shown in Fig. 3.

In addition to providing the proper amount of ventilation during operation, the ventilating fans should be run before starting the oven to clear it of

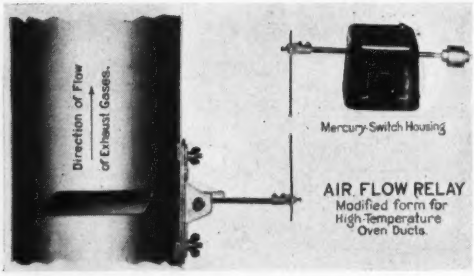


Fig. 2. Air flow relay which interrupts a circuit if the exhaust fan stops or if the dampers close.

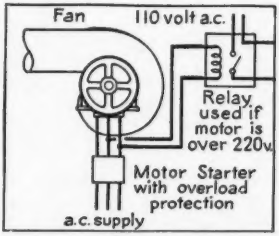


Fig. 3. Direct-driven fan with safety control circuit supplied from the motor terminals.

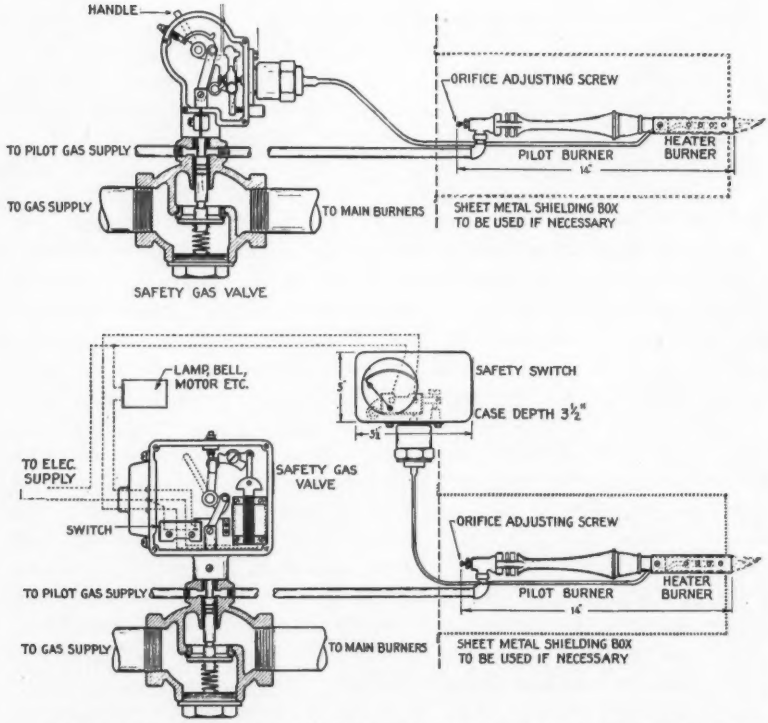


Fig. 4. Heat-operated safety pilot used with a mechanically operated valve (above), and with an electrically operated valve (below).

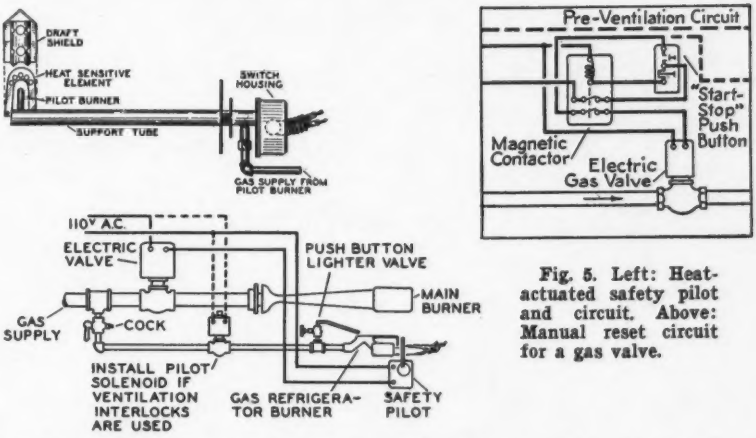


Fig. 5. Left: Heat-actuated safety pilot and circuit. Above: Manual reset circuit for a gas valve.

any flammable vapors or leaking gas which may have accumulated. In order to secure this pre-ventilation a time relay switch is frequently used. Time relays should be of the instant-reset type, so arranged that in event of momentary failure of current they reset to the starting position, and it is necessary to go through the pre-ventilation period before the circuit will again be completed to gas control devices, or to the conveyor motor.

During the operating period and to assist the operator in following the correct lighting procedure, it is desirable to have combustion safeguards on gas and oil-fired equipment. This is particularly important on gas-fired equipment where many explosions have occurred as a result of the failure of the operator to properly light the burners or extinguishment of burners during operation.

The heat-operated safety pilot is useful in many situations and can be used with either a mechanically operated valve or with an electrically operated valve. See Fig. 4. Safety pilots of this type have a heat sensitive element located in the pilot burner flame, and in event of failure of the pilot flame, this element cools, resulting in operation of the device to shut off the main burners. These devices should operate in not more than 30 seconds after the pilot is extinguished. Some are available which operate in less than 10 seconds. Safety pilots should be arranged to shut off the pilot burner flame. Due to the difficult operating conditions in industrial ovens, such devices must pass a rigid test procedure.

For large and important installations various devices using the flame conductivity principle are available which are instant in operation. In these devices the burner flame itself completes a sensitive electric circuit. If the flame fails, the electrical circuit is interrupted and the device immediately shuts off the gas supply. Devices operated by radiant energy are also avail-

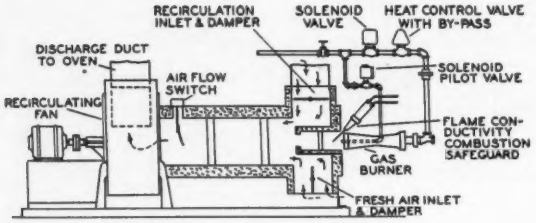


Fig. 6. Direct fired oven heater.

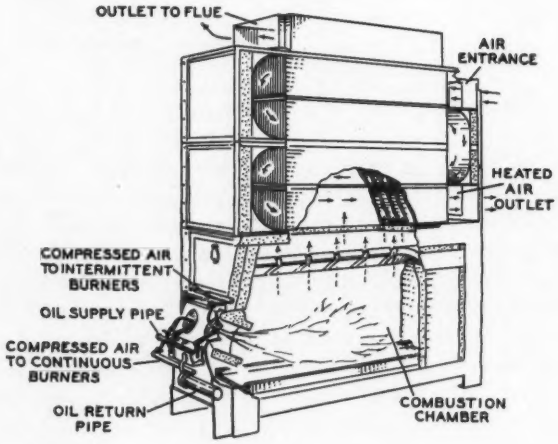


Fig. 7. Indirect fired oven heater.

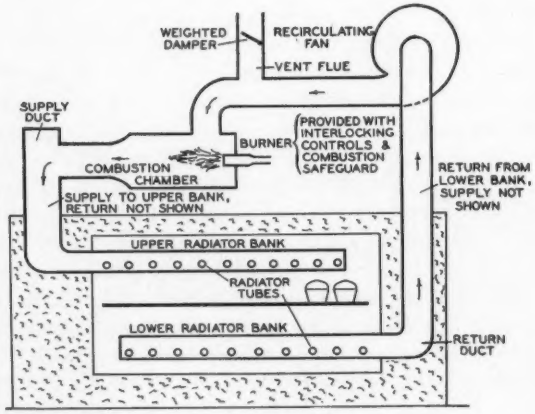


Fig. 8. Indirect recirculating type traveling hearth bakery oven.

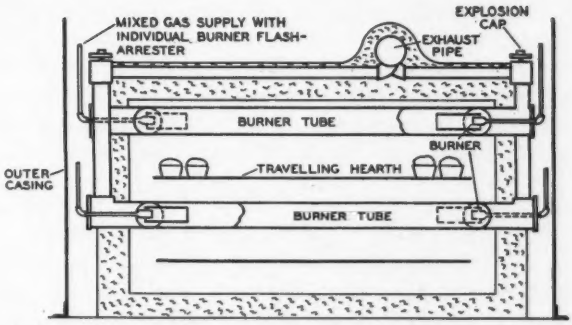


Fig. 9. Enclosed burner type traveling hearth bakery oven.

able and useful on oil burner installations. The gas safety pilot is also for oil-fired oven heaters.

For use with various types of combustion safeguards and other controls, electric gas and oil valves are necessary. Electric valves must be designed to close immediately if the current supply is interrupted. Circuits used with these valves (see Fig. 5) are so arranged that the valve will not reopen automatically, but must receive manual attention before they can be reopened. In a few cases full automatic controls are arranged so that the valves will open automatically if safe conditions are restored and the ignition system operating properly. Many types of valves are available in a wide range of sizes and pressures.

Another development is the approved oven heater, a complete external heating unit, used particularly with japan ovens, and more recently on annealing and drawing furnaces. One type of direct-fired approved heater, shown in Fig. 6, is equipped with all the necessary controls, a ventilation interlock, time relay, and a combustion safeguard of the flame conductivity type. In this heater, products of combustion mixed with fresh air and some recirculated air from the oven are discharged into the oven through ductwork. The installation of these approved heaters has brought about a marked reduction in the number of oven explosions. Other types of approved heaters are available for use with oil equipment. Some approved heaters are indirect-fired (see Fig. 7) so that products of combustion or unburned gases cannot enter the oven.

In addition to oven heaters there are complete approved ovens especially designed for bakery use. The indirect heated bakery oven, shown in Fig. 8, is provided with external recirculating heaters which deliver their products of combustion through ducts to a system of radiator tubes inside the oven. The internal tubes are designed to withstand explosion pressures and the ducts are provided with explosion-venting panels. In addition, to reduce the pos-

sibility of blowing out these panels, the burner is equipped with complete combustion safeguards.

In another type of these ovens (Fig. 9), burners are enclosed in tubes designed to withstand internal explosion pressures, thus keeping the gases or products of combustion entirely out of the oven chamber. The same operating principle has recently been adapted to heat-treating furnaces, using radiant enclosed tube-type burners.

In new installations many approved heaters and approved ovens have been installed. With existing ovens the problem is more difficult, as it is in many cases very difficult to adapt an approved heater or to provide adequate safeguards at a reasonable cost. For these ovens, however, pre-ventilation systems should be installed and equipment arranged so that burners will be extinguished in case of gas failure. A control circuit has been recently developed making it necessary for the operator to have all burner cocks closed before gas can be admitted to the burner piping.

In our oven protection work we have received splendid coöperation from oven manufacturers, and at the present time we find the manufacturers in general interested in safety and more than willing to assist us in the safe arrangement of their equipment.

Southern Tornadoes, April, 1936.

The Southern tornadoes early in April, 1936, were unusually destructive in that their force was spent upon business and residential sections of cities rather than in open country. More than four hundred persons were killed, two thousand were injured, and millions of dollars worth of property damage was caused by these storms between April 2nd and 6th. The great loss of life and property damage which resulted have been widely publicized, but comparatively little detailed data have been recorded of the part which fire played in these disasters.

Greensboro, N. C.

A tornado on April 2, 1936, swept on a narrow path for a distance of more than three miles through the city. In several instances damage included breaking of sprinkler piping, which interrupted fire protection and caused water damage in addition to that due to the heavy rain which accompanied the tornado. Two transformers on poles were thrown to the street and oil escaped and ignited, but burned itself out without damage.

Tupelo, Miss.

At 8:55 on the evening of April 5, 1936, a tornado passed through a residential section of Tupelo, Miss., destroying dwellings, schools, churches

and a hospital, causing heavy loss of life. The storm missed the business district by a quarter of a mile. It wrecked the 100,000-gallon elevated public water tank and tower, and blew down power lines supplying the city, crippling the pumps and leaving the city without power, light or water. Engineers did excellent work in installing an emergency power line to the pumps, and water service was restored in about an hour, although the pressure was low until valves controlling broken connections could be shut.

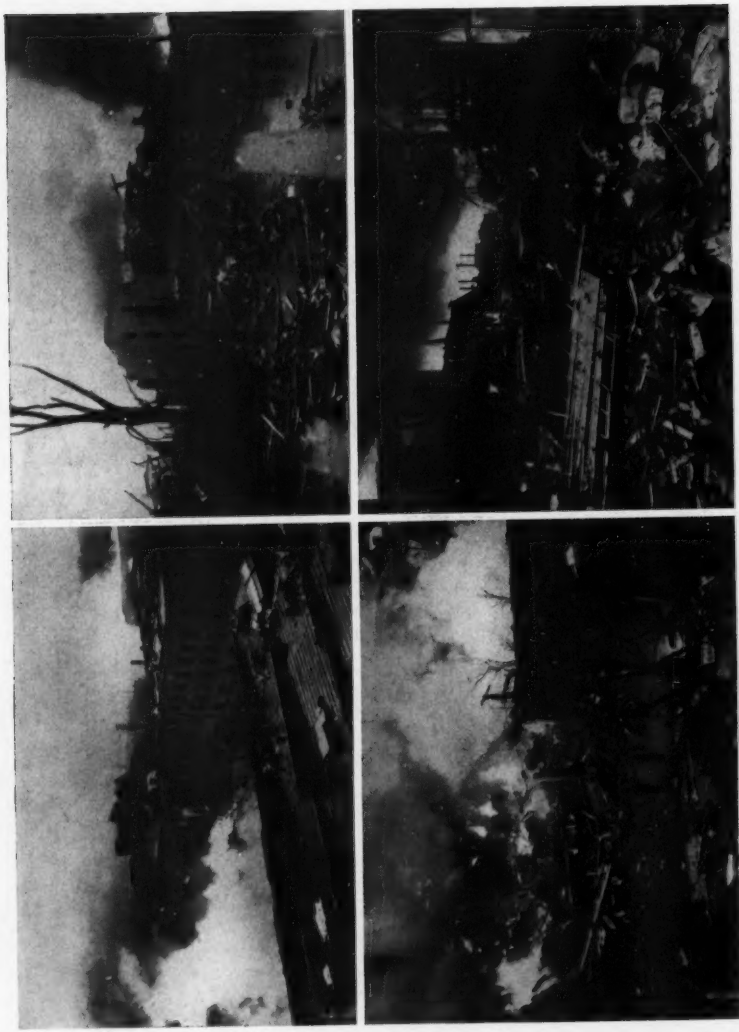
Gainesville, Ga.

This city was probably the hardest hit of all the places visited by the tornadoes. The Red Cross reports 149 persons killed and approximately 800 injured out of a population of about 8600. The tornado developed west of Gainesville and struck the city at 8:45 A.M. on April 6, 1936. The path of the tornado, which was several blocks in width, crossed the entire mercantile district. Although mostly of substantial brick construction, all of the 148 buildings in the business center suffered some damage, and fifty were either severely damaged or totally demolished. Outside of the mercantile district 275 dwellings were totally destroyed and 130 were severely damaged. A hosiery mill and a large cotton mill were severely damaged. The total property damage in Gainesville was between eight and ten million dollars.

Fires Following Tornado.

At least five fires broke out following the tornado. The center of the storm passed directly over the one and three-story brick joisted buildings of the Pruitt Hardware Company, lifting off the roofs and tearing down the walls to street and floor levels. With employees trapped in the wreckage, fire broke out from a gas-heated pressing boiler in one of the buildings used as a clothworking factory. The broken sprinkler piping was useless, and with no fire-fighting or rescue facilities immediately available the fire burned out of control and a number of employees, variously estimated at from fifty-seven to one hundred, lost their lives. Most of these employees were women. It is impossible to obtain information as to the exact circumstances of these deaths, but it appears that the employees were trapped in the building and that many of the fatalities were primarily due to the fire rather than to injuries due to the collapse of the building.

In the same group of buildings, but separated by a fire wall, were two warehouses containing 2600 bales of compressed cotton of the Chicopee Manufacturing Corp. Employees from the Chicopee mill, which escaped the tornado, were rushed to the warehouses with hose and extinguishers. Due to failure of the city water pressure the hose was of little use, but extinguishers and water pails were successfully used in saving the cotton.



Fires burning in the ruins of buildings damaged by the tornado which struck Gainesville, Ga., on April 6, 1936.

Fires burning in the ruins of buildings damaged by the tornado which struck Gainesville, Ga., on April 6, 1936.

Fire Department Activities.

The fire department station was practically demolished by the tornado, but the apparatus was undamaged and the firemen escaped injury. Débris blocked the doors and prevented removal of apparatus. The telephone system which furnished the only fire alarm service was interrupted, but within a few minutes firemen noted fires in two buildings in different blocks within two hundred feet of their station. As the pumper could not be moved the firemen supplied it with two lines of hose from the nearest hydrant and laid one line from the pumper. This was operated alternately on the two fires. Calls for assistance were immediately sent, but before help arrived fires were reported in three other blocks of the business district. Within an hour help began to arrive. By 3 P.M. seven cities, including Atlanta, had supplied five pumpers and three hose trucks. Fortunately the hose threads of these departments had been standardized in 1931. Due to the low water pressure, direct hose streams could not be used, and there was insufficient water to supply all pumpers simultaneously. The work of the different departments was well coördinated, however, and streams were used alternately on different fires as conditions would permit.

Water Supply.

Prior to the tornado, the water system was in normal operation, with eighty pounds static pressure in the mercantile district. When the tornado struck, the pressure immediately dropped to twenty-five pounds, due to broken sprinkler and service connections. The pumping station, the electric power line supplying it, and the elevated tank escaped damage and were operated at capacity, augmented by a fire pump at the Gainesville Cotton Mills, which took suction from the mill pond and pumped into the city system. Gate valves for broken services were closed as promptly as possible. The water supply, while limited, was sufficient to control the fires by nightfall.

Conclusions.

Considering the tremendous handicaps, the fire protection services appear to have been extremely well handled in these disasters. Public departments appear to have made utmost use of all available facilities and to have used good judgment. Mill officials and employees, as well as insurance company representatives, deserve commendation for their intelligent efforts to restore sprinkler systems, fire pumps and other protective equipment. Despite the heavy rains which continued for several days following the tornado, both temporary and permanent repairs were made in a very short time.

NOTE: This account has been prepared from reports published by the South-Eastern Underwriters Association and the Associated Factory Mutual Fire Insurance Companies. (Members N.F.P.A.) The photographs have been furnished by the *Factory Mutual Record*.

Burning of heavy timber fender guard at base of a giant tower of the San Francisco-Oakland Bay Bridge. The fire was controlled before the structural steel was damaged.

San Francisco-Oakland Bay Bridge Fire.

Report by Board of Fire Underwriters of the Pacific,
(Member N.F.P.A.).

The world's largest bridge, spanning San Francisco Bay and costing $75,000,000 to construct, was threatened by fire on April 6, 1936, the week in which the east span was closed with eyebars, linking San Francisco and Oakland for the first time. Construction of the bridge is expected to be completed in the fall of this year. Fortunately the fire, while spectacular and threatening, was controlled without damage to the structural steel towers or loss of life to the sixteen workmen who were temporarily trapped. The damage was approximately $10,000.

Story of the Fire.

The fire occurred at 11:12 A.M. in a fender guard of heavy creosoted timber and piling at the base of one of the steel towers known as Pier E-3. It was discovered by the crew of one of the company boats. They immediately sought more help and returned to fight the fire with hand extinguishers and pails of sand. This attempt was unsuccessful and nearly cost the lives of sixteen men fighting the fire. They were forced to cling to the timbers until rescued by a boat from a near-by island.

As the fire increased in volume an alarm was sent to Fireboat No. 1 of the San Francisco fire department which responded and was followed at 11:42 A.M. by Fireboat No. 2. The boats upon arrival went to work with heavy streams. As soon as conditions permitted, No. 2 boat tied up to the pier and the crew went to work with hand lines and overhauled the entire pier.

Cause and Damage.

The fire is thought by bridge authorities to have been caused by a hot rivet, as a gang of riveters was working directly over where the fire originated, but as there is no evidence to prove this theory the origin has been classified as unknown. It is possible that the fire was caused by a hot clinker from a rivet-heating forge or even from a cigarette.

Bridge engineers state that no damage was done to the structural steel of the towers. The concrete pier was spalled in places to a depth of one and one-half inches, but did not expose any of the reinforcing steel. This spalled concrete was to be built up with gunite to its original dimensions and, according to engineers, would be as sound as before the fire. The fender guards required entire replacement.

Defiance Pressed Steel Company Fire.

The city of Defiance, Ohio, suffered a severe blow on June 13, 1936, when a $500,000 fire destroyed the Defiance Pressed Steel Company plant, one of the leading industries of this small city, and threw four hundred men out of employment. In an effort to induce the plant officials to rebuild in Defiance rather than accepting attractive offers from other cities, the city council following the fire appropriated $50,000 for new fire fighting equipment and voted for the erection of a 300,000-gallon reservoir and larger water mains for the factory district.

The plant consisted of six one-story brick structures and covered an area of approximately four acres. The buildings had concrete floors, but had combustible roof construction. Partition walls between the buildings did not extend through the roof. Products of the plant were largely automobile stampings and accessories, such as heaters and steering wheels. It had been planned to add two hundred men to the payroll the week following the fire in order to increase the production of automobile heaters. A new paint shop under construction was undamaged by the fire. Among the sections destroyed were the heater department, pressed steel building, steering wheel department, tool department and warehouse.

Story of the Fire.

The fire occurred at 10:40 A.M. Saturday morning while approximately two hundred workmen were in the building. It was discovered in a storeroom adjoining the automobile heater department.

The fire started in a stock of rubber heater hose wrapped in burlap which formed a pile approximately fifteen feet in diameter and equally high. Chemical equipment and hose from a plant hydrant were immediately used, but neither were effective. Water pressure was exceedingly low, so that the hose stream did not reach the fire. Had there been sufficient pressure to break the pile of burning material the fire could have been promptly controlled. Fumes from the burning rubber soon drove the workmen from the building and the fire spread quickly beneath the wooden roof.

The alarm was sounded by telephone and from a near-by public box. When the fire department, a largely volunteer organization, arrived about one-half of the wing in which the fire started was burning. A pumper and a combination hose truck answered the first alarm and a second pumper was immediately called. These pumps were old and of very small capacity. One soon went out of service due to a defective bearing. The firemen laid four

NOTE: The account of this fire has been prepared from a report by the Ohio Inspection Bureau (Member N.F.P.A.) and other information from local sources.

A weak water system and inadequate public and private protection were responsible for the destruction of the Defiance Pressed Steel Company plant at Defiance, Ohio, on June 13, 1936. Note the small boys at the left of the picture, attempting to move one of the hose lines.

lines of hose, but found the water pressure and volume inadequate to provide effective streams. Pumpers called from the towns of Napoleon and Holgate arrived about 11:45 A.M. The Napoleon pumper, of 1000 gallon per minute capacity, was used to replace the one which had broken down, and somewhat increased the effectiveness of the streams. The booster tank of the Holgate pumper was used to protect near-by buildings, including a gasoline bulk station. No heavy stream appliances were available and the few small streams had little effect on a fire of this magnitude.

The fire early spread through the heater building and by 11 A.M. the walls of several buildings had collapsed. It was at first hoped that the steel pressing building might be saved, but at 11:30 flames extended to the roof at the center of this building, and firemen were unable to save the structure. A fairly brisk wind aided the fire. Considerable finished product was removed from the warehouse section during the fire, but a portion of this was ignited by flying embers.

The fire is generally attributed to spontaneous ignition within the pile of baled rubber hose, either in the rubber, the burlap wrapping, or some foreign material. Another theory is that the sun's rays were concentrated on the rubber hose by passing through a skylight. The damage to the buildings of the plant was estimated at more than $100,000. Destruction of valuable machinery, tools, patterns, and of merchandise stored in the warehouse is estimated to have brought the total damage to nearly $500,000.

Fire Record of Churches.

Church fires occur on an average of three each day in the United States. Divine Providence, which would appear to be generally the principal reliance for the fire safety of churches, has not exempted these structures from destruction by fire, judging from reports of six hundred and fifty-six fires on file with the N.F.P.A. Department of Fire Record. Fire, like rain, "falls upon the just and unjust" in accordance with natural laws, and churches are daily paying the inevitable penalty for improper construction and indifference to fire protection and fire hazards.

Churches, because of the character of their occupancy, with less of the usual hazards attendant upon residence, commercial and special hazard occupancies, would appear to present comparatively few opportunities for the start of fire. The favorable consideration is offset, however, by inferior construction, defective heating and lighting installations, lack of lightning protection for steeples particularly exposed to this hazard, and a grade of supervision and maintenance frequently not comparable to that found in other types of property. Many churches are located in areas where fire equipment and water supplies are designed to protect residences, and are inadequate for much larger structures. Even when located in congested sections under strong protection, delayed discovery of fire and weak structural conditions often make for large losses.

While the average monetary loss in church fires is unusually large, no major holocausts involving great loss of life have as yet occurred in American or Canadian churches to direct public attention to the construction and protection of this class of property, which has not received the consideration accorded to theatres and schools, occupancies having many similar characteristics.

The reports on which the following statistical tables are based are of fires most of which have occurred since January 1, 1920. While the number of fires reported to the N.F.P.A. is but a small fraction of the total number that have occurred during this period, the volume of data is sufficient to draw general conclusions as to the predominating causes of church fires, the method of their spread, the effectiveness of protection and like details. The N.F.P.A. record has been supplemented by the following table giving loss figures for eight states and one large city, for which figures on church fire losses are available. On the basis of these representative areas comprising one-fifth of the total population of the United States, it is estimated that for the past ten years church fires have occurred at the rate of approximately eleven hundred annually, and losses have exceeded $5,000,000 each year. The table also

All that remained of the St. Jean Baptiste Church at Ottawa were the solid brick exterior walls. The interior, of wooden construction throughout, was entirely destroyed, with a loss of $484,000, on February 8, 1931.

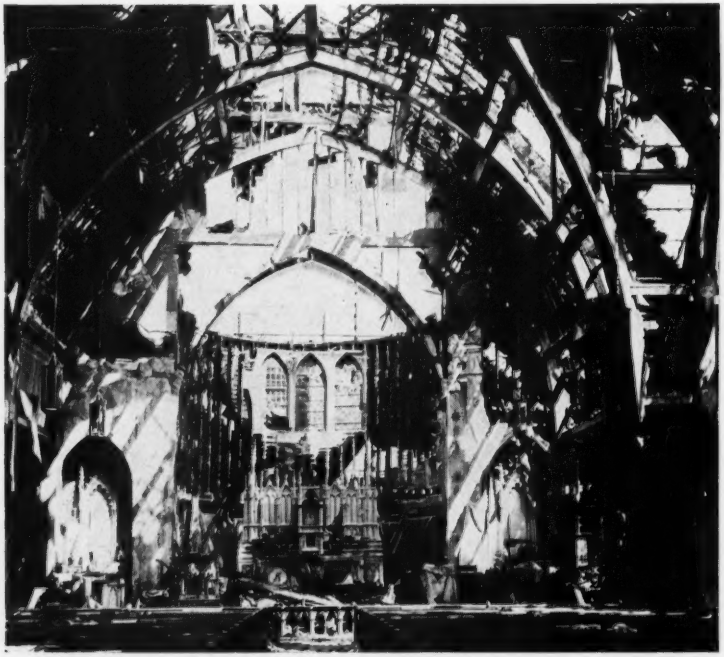
shows the average loss per church fire. The figure of $4873 average church fire loss is considerably higher than that of most occupancies. The average dwelling fire loss for a similar period in almost the same group of states was but $591. The high average church fire loss in Massachusetts is believed largely due to higher average values of church structures and older types of construction which are more susceptible to destruction by fire.

United States Fire Record of Churches.

(Latest Ten-Year Periods Available)

State or City	Period Covered	Population (1930 Census)	No. Fires Ten Years	Total Loss Ten Years	Average Loss per Fire
Illinois	1925-34*	7,607,000	619	$2,699,410	$4,361
Iowa	1926-35	2,468,000	240	1,159,746	4,832
Kansas	1924-33	1,880,000	167	796,414	4,769
Louisiana	1925-34	2,094,000	248	401,925	1,621
Massachusetts	1925-34	4,253,000	341	3,288,130	9,643
South Dakota	1926-35*	691,000	40	117,598	2,940
Vermont	1925-34	359,000	102	158,953	1,558
Wisconsin	1924-33	2,930,000	216	1,136,067	5,259
Philadelphia, Pa.	1926-35	1,964,000	189	777,601	4,114
Total	Ten years	24,246,000	2,162	$10,535,844	$4,873
Estimated U. S. Total	Ten years	122,700,000	10,946	53,346,000	4,873

*Fiscal year ending June 30.



Acme.

Ruined interior of St. Francis de Sales Catholic Church in the Belle Harbor section of Brooklyn, N. Y., after the fire of April 26, 1935. Concealed spaces behind the altar and the false roof behind which the fire extended may be readily seen.

Building and Contents Losses.

The division of church losses between structure and contents is shown by ten-year figures for two representative states and one city. As would be expected, contents losses are a much smaller proportion of the entire loss than is true of most occupancies. Such losses are however considerable in the aggregate, and in a year losses to contents of churches undoubtedly approach $1,000,000.

Division of Losses Between Buildings and Contents.

(Most Recent Ten-Year Totals.)

State or City	Buildings Loss	Buildings Per Cent	Contents Loss	Contents Per Cent	Total Loss
Iowa	$969,744	83.5	$190,002	16.5	$1,159,746
Massachusetts ..	2,810,830	85.4	477,300	14.6	3,288,130
Philadelphia, Pa.	658,885	84.8	118,716	15.2	777,601
Total	$4,439,459	85.0	$786,018	15.0	$5,225,477

Per Cent of Loss to Value Involved.

The following table shows the per cent of loss to property involved in church fires in three representative states. While figures for three states cannot be considered a conclusive indication of national experience, the high loss ratio for these states, together with the high loss per fire already shown, serves to emphasize the fact that individual losses are large, and indicates the need for greater efforts toward fire protection for churches.

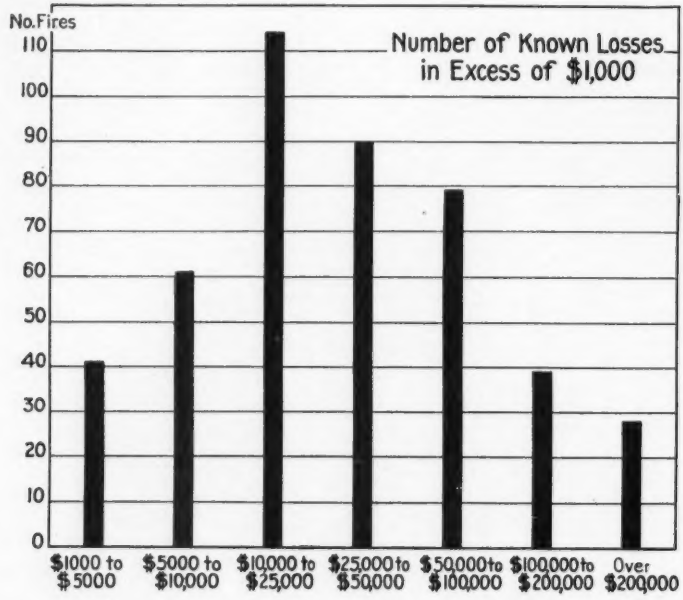
State	Value Involved in Fires	Loss	Per Cent Loss
Indiana (five-year totals)	$3,653,155	$688,322	18.8
Louisiana (ten-year totals)	3,068,261	401,925	13.1
Wisconsin (ten-year totals)	7,101,756	1,136,067	16.0
Total	$13,823,172	$2,226,314	16.1

Underwood and Underwood.

Notre Dame Basilica, P. Q., destroyed with a loss of $350,000 on December 22, 1922. The roof and interior of this stone walled church were of wood. The origin of the fire is unknown, but has been variously assigned to electric wiring and incendiarism. When the fire department arrived a considerable portion of the church was ablaze and the department, though seriously handicapped by lack of water, did good work in confining the fire to the church proper.

N.F.P.A. Analysis of Loss.

The following chart shows the magnitude of losses occasioned by church fires which have been reported to the N.F.P.A. Department of Fire Record. In addition to the losses shown on the chart, 135 fires were reported in which the loss was under $1000 or small; 61 fires were reported as large but without specific figures, and there were eight fires reported for which no loss figures were given.



Although N.F.P.A. fire records customarily contain a greater portion of the larger losses occurring in any occupancy, as smaller losses are frequently not reported to the Department of Fire Record, the number of large loss church fires is unusually high. The following fires are typical of those which have destroyed many noted and costly churches in recent years. Aside from monetary values many churches have historical and sentimental associations which are irreplaceable.

Typical Large Loss Church Fires.

Date		Loss
March 29, 1922.	Ste. Anne de Beaupré, Ste. Anne, P. Q.	$300,000
April 3, 1922.	Sacred Heart, Montreal, P. Q.	400,000
December 22, 1922.	Notre Dame, Quebec, P. Q.	350,000
July 11, 1924.	First Methodist Episcopal, McKeesport, Pa.	150,000
November 22, 1924.	St. Vincent de Paul, Montreal, P. Q.	200,000

Acme.

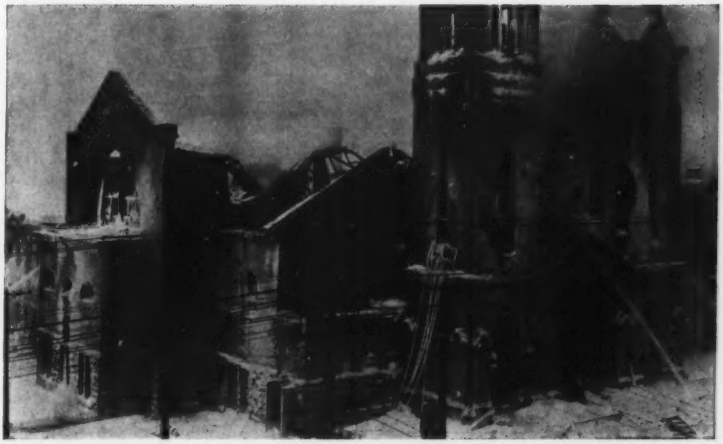
Destruction of the one hundred year old Hunt's Memorial Methodist Church at Riderwood, Md., on February 12, 1933. As in the case of many rural church fires, the fire department streams were ineffective and in a short time flames burst through the wooden shingle roof and destroyed the structure.

April 15, 1925.	Holy Trinity Episcopal, New York, N. Y.	500,000
October 29, 1925.	Annunciation, Shenandoah, Pa.	150,000
February 6, 1926.	Grace Congregational, Framingham, Mass.	150,000
August 14, 1926.	Louisville Church, Maskinonge, P. Q.	200,000
December 3, 1926.	Second Congregational, New London, Conn.	150,000
February 5, 1927.	First Congregational, Toledo, Ohio (3 killed)	205,000
December 25, 1927.	Church of Our Lady, Harrison, N. J.	300,000
January 30, 1928.	Metropolitan United, Toronto, Ont.	400,000
April 4, 1928.	St. Philip's Catholic, Battle Creek, Mich.	260,000
January 7, 1929.	Gary Memorial M. E., Wheaton, Ill.	300,000
January 12, 1929.	First Baptist, Fort Worth, Tex.	280,000
December 1, 1930.	Second Presbyterian, Newark, N. J.	250,000
December 27, 1930.	St. Joseph's Catholic, Ottawa, Ont.	418,000
January 29, 1931.	St. Denis, Montreal, P. Q.	325,000
February 2, 1931.	Church of the Angel Guardian, Montmorency Co., P. Q.	165,000
February 8, 1931.	St. Jean Baptiste, Ottawa, Ont.	484,000
February 24, 1931.	Hope Congregational, Springfield, Mass.	200,000
March 14, 1931.	Trinity M. E., Albany, N. Y.	200,000
April 20, 1931.	North Reformed, Newark, N. J.	175,000
October 20, 1931.	Harvard Congregational, Brookline, Mass.	251,000
November 15, 1931.	Richmond Hill M. E., New York, N. Y.	200,000
November 18, 1931.	Crescent Avenue Presbyterian, Plainfield, N. J.	200,000
January 30, 1932.	All Saints Episcopal, Worcester, Mass.	180,000

Courtesy Fire Engineering.

Fighting the fire of unknown origin which caused $100,000 loss in the First Methodist Episcopal Church of Kalamazoo, Michigan, on March 13, 1926.

March 8, 1932.	Holy Trinity Catholic, Bloomington, Ill.	368,000
March 12, 1932.	St. Mary Magdalene Catholic, Homestead, Pa.	250,000
January 12, 1933.	St. Louis de France Catholic, Montreal, P. Q.	410,000
March 26, 1933.	St. Jacques le Mineur Catholic, Montreal, P. Q.	657,000
May 2, 1933.	First Methodist, Rochester, N. Y.	156,000
September 22, 1933.	Valleyfield Catholic Cathedral, Valleyfield, P. Q.	512,000
March 16, 1934.	St. Jerome's Catholic, Holyoke, Mass.	280,000
April 1, 1934.	Church of the Assumption and Order Minor Conventuals, Syracuse, N. Y.	310,000
May 31, 1934.	St. Michael's Monastery, Union City, N. J.	532,000
March 21, 1935.	St. Patrick's Catholic, Pittsburgh, Pa.	200,000
January 30, 1936.	St. Anthony's Catholic, Timmins, Ont.	200,000
March 21, 1936.	First Congregational destroyed, Mohammed Temple damaged, Peoria, Ill.	358,000



Originating in the basement during the early morning hours of January 29, 1931, fire in St. Denis Church, Montreal, gained such headway before discovery that it was impossible to save sacred relics or prevent a loss of $325,000.

Denominations in Which Fires Occurred.

Fire visits the places used for worship by different sects and creeds quite indiscriminately. Thirty-four different denominations are represented in the N.F.P.A. record. Denominations for which more than five fires have been reported are shown in the following table. Fire hazards vary somewhat with the practices and customs of the various denominations. For example, some churches make a more general use of candles, which are one of the leading causes of fire, while others not having this hazard contain kitchens and social rooms which add other hazards.

Denominations Represented in N.F.P.A. Fire Record.

	No. Fires
Roman Catholic	202
Baptist	86
Presbyterian	60
Methodist-Episcopal	48
Congregational	45
Methodist	43
Episcopal	39
Lutheran	25
Christian	13
Hebrew Synagogue or Temple	11
Evangelical	10
United	9
Community	7
Unitarian	6
Greek Orthodox	6
All others (less than 6 each)	46
Total	656

The Methodist Church in Ellsworth, Me., ignited by flying brands falling on the wooden shingle roof, was an easy prey to the conflagration which swept the town on May 7, 1933.

Causes of Church Fires.

Most churches are destroyed by fires from a relatively few well-known causes which in most occupancies would be considered the most easily recognized and readily preventable hazards. This is shown by the following table of causes.

Causes of Fires in Churches, From N.F.P.A. Fire Record.

	No. Fires	Per Cent of Known Causes
Overheated or defective furnace or stove	92	20.3
Defective chimney or flue	64	14.1
Defective wiring (not including organ)	51	11.2
Incendiary	34	7.5
Lightning	33	7.3
Candle or vigil light	23	5.1
Organ wiring or motor	22	4.9
Smoking—matches	21	4.6
Sparks on wooden shingle roof	15	3.3
Ignition of rubbish	12	2.6
Exposure or conflagration	11	2.4
Spontaneous ignition of oily material	9	2.0
Oil burner	9	2.0
Blow torches	8	1.8
Spontaneous ignition of bituminous coal	7	1.5
Hot ashes	5	1.1
Gas explosions	4	.9
Oil stove or lamps	4	.9
Gas stove left burning or defective	4	.9
Sparks from roofer's pot	3	.7
Motion picture film ignited	3	.7
Overheated steam pipe	3	.7
Miscellaneous known causes (one or two fires from each cause)	16	3.5
Total known causes	453	100.0
Unknown causes	203	
Total	656	

The outstanding part played in the church fire record by such fire causes as overheated or defective furnaces or stoves, defective chimneys and lighting merits further discussion and illustration by typical fires.

Heating Fires.

It is not surprising that fires due to the heating plant should be frequent, because of the conditions under which they are used. Many churches are largely or entirely unheated during week days and fires are forced for the one or two days when the church is used. An adequate heating plant is not always provided and supervision is sometimes not of the best grade. Typical of fires which have occurred are the following:

METHODIST EPISCOPAL CHURCH, FARMINGTON, ILL., JANUARY 26, 1928. The janitor discovered the fire in the woodwork over the hot air furnace while the Ladies' Aid was holding a meeting. There was but an eight-inch clearance between the furnace and the wooden joists above. After attempting unsuccessfully to control the fire the janitor gave an alarm. The church was destroyed with a loss of $56,000. (H-25552.)

GRACE METHODIST CHURCH, BURLINGTON, IOWA, DECEMBER 3, 1929. The janitor started a fire in the hot air furnace and went home to lunch, evidently leaving the damper open. Combustible partitions near the furnace ignited. The fire was finally noticed by a passer-by who sounded an alarm. The building was destroyed with a loss of $55,000. (H-29448.)

International.

Firemen may be seen operating heavy streams to control the fire which damaged a synagogue in Brooklyn, N. Y., during February, 1936. Occupants of adjoining tenements were forced out into the cold, as firemen carried hose through these structures while fighting the fire.

FIRST CHRISTIAN CHURCH, LAWTON, OKLA., JANUARY 11, 1930. The janitor started the gas-fired hot air furnace at 5 P.M. on Saturday to warm the building for Sunday services. Hot air pipes were in contact with woodwork and fire followed the pipes which were concealed in the walls. Due to a fog the fire was not promptly discovered, and a loss of $18,000 resulted. (H-29134.)

NORTHMINSTER PRESBYTERIAN CHURCH, WASHINGTON, D. C., JANUARY 6, 1935. The church was heated by two hot air furnaces. Two weeks before this fire the janitor had extinguished a fire in the joists over one of the furnaces. On Sunday morning he opened the drafts of both furnaces at 7 A.M., and several hours later discovered smoke and found a fire in the basement. He ran to the near-by home of a church official, who telephoned an alarm at 9:17 A.M. This was followed by five alarms, as the fire spread up through open wooden partitions to the attic over the auditorium and destroyed the roof. The loss was $28,064. (H-38780.)

Defective Flues.

The second greatest cause of church fires and also related to the problem of heating are fires due to defective chimneys and flues. Such fires are frequently chargeable to poor maintenance of buildings. Fires from this cause are particularly serious because they frequently occur in the attic or concealed wall spaces, where they are inaccessible and frequently gain headway before discovery. Improper clearance and deterioration of flues leading to the chimney also have caused frequent fires. The following are typical:

International.

The heavy framework and brick walls are all that remain of Our Lady of Guadalupe Catholic Church in Brooklyn, N. Y. which burned on January 1, 1932, with a loss of $100,000. The cross timbers shown in the picture were located in a concealed roof space through which the fire traveled.

PRESBYTERIAN CHURCH, DUQUOIN, ILL., JANUARY 1, 1928. Fire caused by a defective chimney flue at a point between the auditorium ceiling and roof was discovered by outsiders. Due to weak public fire protection the church, which was of frame construction, was destroyed with a loss of $35,000. (H-25813.)

ST. JOSEPH'S CATHOLIC CHURCH, AMERY, WIS., OCTOBER 6, 1935. The fire occurred at 6:30 A.M., when the furnace was first started for the season. It is possible that the smokepipe may have rusted out, or possibly combustible materials accumulated on the smokepipe during the summer and ignited. When discovered, the fire had extended into the blind loft above the auditorium. The volunteer fire department was unable to save the building. The loss was $12,300. (H-40140.)

Defective Wiring.

Defective electric wiring is the third greatest cause of church fires, and takes second place when fires due to defective organ wiring, which have been considered separately, are added to the total. The chief hazards of church wiring are deterioration of obsolete lighting systems and overloading due to increased demands for electricity. It has not been considered necessary to present typical electrical fires at this point, as the hazards of defective wiring are generally known and are covered under the subject of defective organ wiring.

Incendiary Fires.

Unfortunately churches have frequently been the target of incendiaries, largely because they make notoriously spectacular fires and also because cranks and radicals find them easy to destroy.

SOUTH BAPTIST CHURCH, BOSTON, MASS., FEBRUARY 5, 1928. The most serious of a series of incendiary church fires in the South Boston section of the city destroyed this church. The fire was attributed to a small boy who entered the church looking for money. The loss was $33,000. (H-25699.)

ST. JACQUES LE MINEUR CHURCH, MONTREAL, P. Q., MARCH 6 AND 26, 1933. On March 6 a small fire was discovered in a cupboard under a stairway. The door had been forced from the cupboard and a fire started with newspapers. Fortunately the fire was discovered in time to be extinguished with a chemical extinguisher. On March 26, after warning had been received that the church was to be destroyed, a fire occurred during services. Several women were injured by jumping from the first gallery when the fire was discovered in the upper gallery. The fire spread rapidly and the church was destroyed with a loss of $657,000. (H-36713.)

ST. JOHN'S CATHOLIC CATHEDRAL, MILWAUKEE, WIS., JANUARY 28, 1935. Fire believed to be one of a series of fires of incendiary origin started in a small room under the altar and gained considerable headway before discovery. The church was an old brick structure with a blind attic under the roof and considerable hollow finish in walls and partitions. The roof space was involved when the fire department arrived and the roof burned off before the fire was controlled. The loss was $138,000. (H-39132.)

Courtesy Fire Engineering.

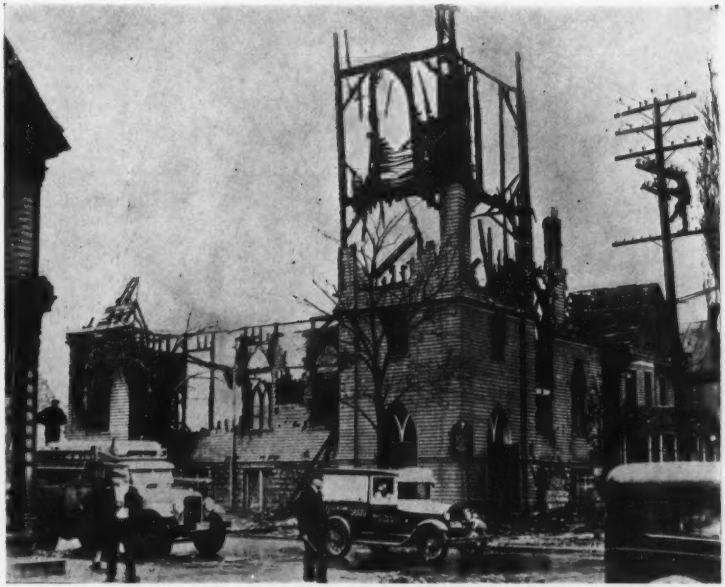
Christ Episcopal Church, New York City, June 26, 1925. This fire is supposed to have originated under the tile-covered gabled roof. The heavy hose streams directed from vantage points on near-by structures were ineffective until the roof burned through.

Lightning.

Church structures are often higher than adjacent buildings and, particularly when provided with lofty steeples or towers, provide a ready path for a lightning charge desiring to get to the earth. As shown by the following typical instances, lightning fires in churches do not always immediately burst into flames, but frequently smoulder and burn for several hours before discovery. Lightning rods should be installed on all churches where there is danger of lightning damage.

BROADWAY METHODIST CHURCH, PADUCAH, KY., JUNE 2, 1929. Lightning was seen to strike near the roof of the church at 5 P.M. during a thunderstorm. About midnight fire, which had gained considerable headway, was discovered in the roof spaces and a loss of $51,263 resulted. It is believed that the lightning followed the wiring system into the attic. (H-27614.)

HOLY ANGELES CATHOLIC CHURCH, ST. CLOUD, MINN., SEPTEMBER 16, 1933. Lightning struck the church and the fire gained great headway in the attic before it was discovered. The church was destroyed, as the fire department was unable to reach the attic fire. The loss was $81,300. (H-37282.)



The American Scandinavian M. E. church and parsonage, Buffalo, N. Y., severely damaged by a fire started on wooden shingle roofs by flying brands from the fire of May 6, 1931, which destroyed the 106th Field Artillery Armory four blocks distant.

ST. JOSEPH'S CATHOLIC CHURCH, TIFFIN, OHIO, APRIL 11, 1934. Lightning struck the one hundred and fifty foot steeple of this historic church during a storm at about 1:30 A.M. At 5:30 A.M. a policeman saw flames in the tower. When firemen arrived flames had spread through the entire length of the roof. The loss was $100,000. (H-38104.)

Candles.

Lighted candles are extremely dangerous when near combustible materials and should not be left burning unattended. In churches where candles and vigil lights are necessary adjuncts to the form of worship, they should be used with care and should be kept away from combustible materials. First aid fire extinguishers should always be on hand to control any fire which may start. Use of candles merely for effect where they have no religious significance should be discouraged as dangerous both to life and property. The following fire is an outstanding example of others from this cause.

ST. JOSEPH'S CATHOLIC CHURCH, OTTAWA, ONT., DECEMBER 27, 1930. Fire occurred when a tray of candles, upset by a small boy worshiper, ignited a manger depicting the nativity of the Saviour. Fire spread to evergreen decorations which lined the interior of the church. The building, valued at $418,000, was destroyed. (H-31660.)

William E. Paterson.

Firemen fought flames in the basement of the St. Mary Magdalene Catholic Church of Homestead, Pa., for several hours on March 12, 1932, before the fire spread to the upper portion of the structure and burst through the roof, as shown in the right-hand view. At the left is one of the twin 150-foot steeples in flames shortly before it crashed to the street.

Organ Wiring or Motor.

Organ wiring and motors are not only a leading cause of church fires, but are a particularly serious hazard because they frequently cause fires that are practically inaccessible, unless quickly discovered. Organ lofts often communicate directly with the attic or roof space, and in some instances form an open space from the basement to the roof. Organ motors, if left on, may overheat and cause fire while the church is unoccupied. Some well-managed churches follow the desirable practice of having the organ completely inspected once each year. Such a practice not only contributes to the proper care and performance of a valuable instrument, but it greatly adds to the fire safety of the church. The following fires are typical:

THIRD PRESBYTERIAN CHURCH, NEW ORLEANS, LA., JANUARY 27, 1926. Members of the congregation discovered smoke in the basement and called the fire department, who found the smoke coming from a two H.P. 220-volt, 3-phase organ motor which fortunately was enclosed in a sheet metal housing. The last person using the organ forgot to turn off the switch and the motor "froze" to the shaft due to lack of oil. When the bearings stuck, one fuse blew, but single phase current continued through the windings with the rotor stalled. (H-25143.)

EAST CONGREGATIONAL CHURCH, EAST CLEVELAND, OHIO, MAY 1, 1928. The motor for the pipe organ was left running and overheated. Fire spread to the wood box covering the motor and extended through the wood joist floor above the basement and burned the pipe organ, organ room and pulpit section. Fortunately the fire was soon discovered by an outsider who called the fire department. Loss $5300. (H-26163.)

HARVARD CONGREGATIONAL CHURCH, BROOKLINE, MASS., OCTOBER 20, 1931. Fire, believed due to defective organ wiring or motor, started beneath the organ and spread throughout the large stone-walled structure. An electrical engineer on the scene at the start of the fire and familiar with church organs stated that when the fire department arrived the fire was entirely confined to the organ. The loss was $251,000. (H-32950.)

FIRST METHODIST CHURCH, ROCHESTER, N. Y., MAY 2, 1933. Fire starting from a short circuit of old wiring on the organ spread through the large stone church structure, which was seriously damaged. Loss: $155,994. (H-37334.)

Sparks on Wooden Shingle Roofs.

Wooden shingle roofs are no respecter of churches, as is shown by the N.F.P.A. fire record, which contains fifteen fires from this cause. Even more striking is the record of church fires in Kansas, shown on page 85, where sparks on roofs was the leading fire cause and started nearly eighteen per cent of all church fires in the state. Large losses are very likely when wooden roofs of churches ignite, as fire quite frequently spreads over the roof before the fire department can go into action.

Fire in the famous church of Ste. Anne de Beaupré at Ste. Anne, P. Q., which was destroyed on March 29, 1922, with a loss estimated at over $300,000. The fire, discovered in the sacristy in the rear of the church, was fanned by a strong wind and spread simultaneously towards the roof of the cathedral on the west side and to the roof of the monastery on the east side. These were quickly destroyed, but the fire made slower progress in the church. Villagers did what they could to fight the fire, but were practically powerless until the firemen arrived from Quebec. Lack of water prevented effective work by the firemen and the structure was almost entirely destroyed. The famous statue of Ste. Anne, to which are attributed miraculous powers, was saved. A temporary basilica, constructed following this fire, was also destroyed by fire on November 9, 1926.

St. Paul's Church, Newburyport, Mass., April 27, 1920. This fire occurred about 3 a.m. and was first noticed on the roof of the main part of the building near a rear addition. When the fire at the rear of the building near where it started appeared to be under control, it suddenly broke out at a point in the church tower at the other end of the building, having apparently spread through the open loft of the building. This church was a local landmark with many historic associations.

AMERICAN SCANDINAVIAN M. E. CHURCH, BUFFALO, N. Y., MAY 6, 1931. Flying brands from the fire which destroyed the 106th Field Artillery Armory four blocks distant ignited the wooden shingle roof of the church. With the fire department engaged at the armory fire, the church was practically destroyed and the fire spread to the adjoining parsonage, which was badly damaged. Loss: $17,869. (H-32701.)

HEBRON COMMUNITY CENTER CHURCH, LOS ANGELES, CALIF., MARCH 10, 1935. As children were gathering in the building for Sunday School a chimney spark ignited the wooden shingle roof. Neighbors seeing the smoke led the children from the building. The fire spread so rapidly that a portion of the roof collapsed shortly afterward. The loss was $10,000. (H-39022.)

Causes of Church Fires—State of Kansas.

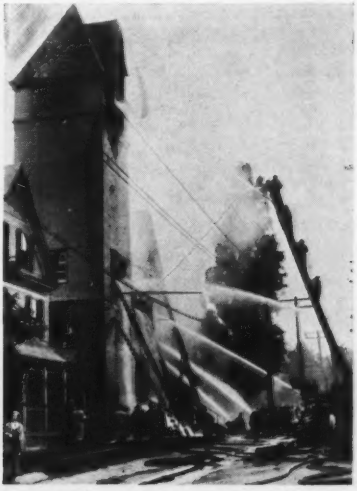
An interesting tabulation of the cause of church fires is presented by figures from the State of Kansas. As shown by the following table, the leading causes of church fires, in addition to sparks on roofs, are heating fires, defective chimneys, and lightning. Lightning caused the greatest monetary loss. A very interesting comparison is shown between the almost negligible loss in churches protected by lightning rods as compared with the loss in unrodded churches.

Causes of Church Fires — Kansas.

1924-1933.

	No. Fires		Loss	
	No.	%	Amount	%
Chimneys and stacks, overheated or defective	19	11.4	$97,368	12.2
Electricity	7	4.2	59,209	7.4
Explosions (other than petroleum)	2	1.2	700	.1
Exposure	7	4.2	13,261	1.7
Fireworks	1	.6	150	.0
Friction	1	.6	5,000	.6
Gas	1	.6	100	.0
Hot ashes	1	.6	10	.0
Hot grease, tar, wax, etc.	1	.6	150	.0
Incendiarism	2	1.2	6,225	.8
Lightning—rodded	3	1.8	295	.0
Lightning—not rodded	10	6.0	180,232	22.6
Miscellaneous known causes	3	1.8	13,125	1.7
Open lights	1	.6	5	.0
Rubbish and litter	6	3.6	42,502	5.4
Smoking	3	1.8	1,828	.2
Sparks on roof	30	17.9	70,306	8.8
Other sparks	9	5.4	7,128	.9
Spontaneous ignition	7	4.2	6,715	.9
Stoves, furnaces, boilers and their pipes	26	15.6	114,870	14.4
Unknown	27	16.1	177,235	22.3
Total	167	100.0	$796,414	100.0

Newark Evening News.



International.

Large amounts of water are frequently necessary in fighting church fires. The Winter Hill Baptist Church in Somerville, Mass., at the right, was practically destroyed on June 17, 1933, in spite of the heavy battery of hose streams shown. At the left is shown the interior of the North Reformed Church of Newark, N. J., which suffered $175,000 damage on April 20, 1931. Even where firemen are careful in the use of water and salvage covers are used, water damage can not always be avoided.

Causes of Church Fires—Massachusetts.

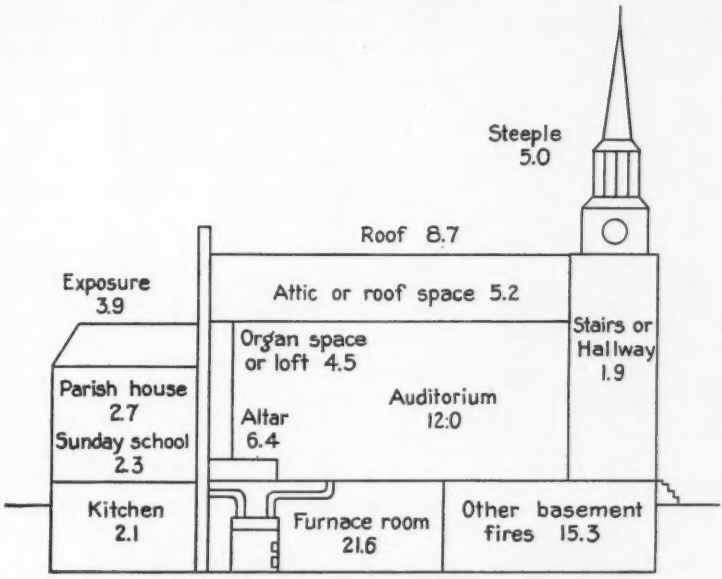
The following table of church fire causes in Massachusetts is interesting because the number of fires reported is sufficient to give a reliable indication of the leading fire causes. The large number of fires attributed to careless smoking is surprising, as smoking is frequently restricted in churches. Sparks from chimneys, most of which ignited wooden shingle roofing, is the second greatest fire cause.

Causes of Church Fires—Massachusetts.
1925-1934, inclusive.

	No. Fires	Per Cent
Burning soot	3	.9
Careless smoking	36	10.5
Careless use of matches	16	4.7
Children and matches	5	1.4
Defective chimney	23	6.7
Defective heating apparatus	4	1.2
Defective heating apparatus (oil burning)	10	2.9
Electrical causes	27	7.9
Fireworks	7	2.1
Heating or lighting apparatus igniting contents	33	9.7
Hot ashes	10	2.9
Ignition of flammable liquids	3	.9
Incendiary	9	2.6
Lightning	24	7.0
Malicious mischief	4	1.2
Mechanics' torches	4	1.2
Overheated cooking or heating apparatus	27	7.9
Range oil burners	3	.9
Sparks from bonfires, etc	6	1.8
Sparks from chimneys	35	10.3
Sparks from furnaces, stoves, etc	10	2.9
Spontaneous ignition	19	5.6
Thawing water pipes	3	.9
Miscellaneous known causes	6	1.8
Unknown	11	3.2
Unknown, suspicious	3	.9
Total	341	100.0

Point of Origin of Fires.

In planning to control the fire menace in churches it is desirable to know not only what are the most frequent causes of church fires, but where such fires are most likely to occur. A defective chimney may cause fire in the basement, in the wall spaces or in the attic near the roof. Lightning fires may occur at the steeple or burn out wiring in the attic. The following diagram has been prepared to show the most important locations where fires start. From a study of this chart it can be readily seen that by providing automatic fire protection for the basement, organ space, and attic a large degree of security might be obtained. The attic space is an extremely important point because of its inaccessibility for fire fighting, and because fires starting at lower points quite frequently extend upward into the attic area.



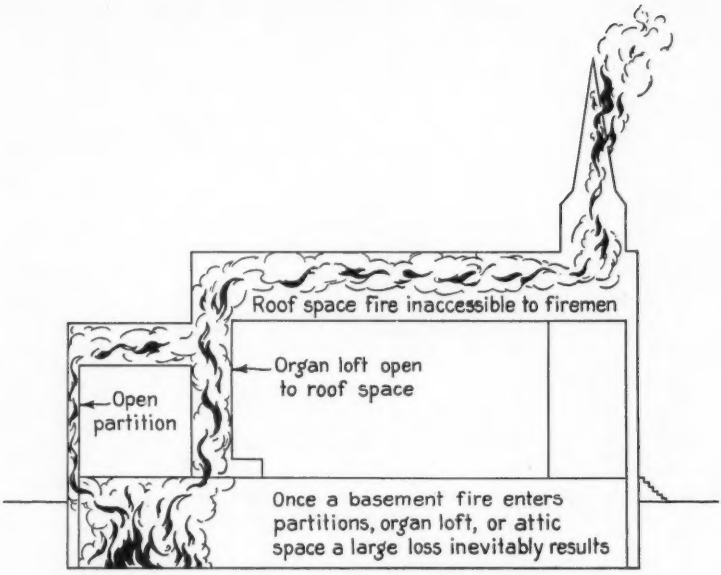
Point of origin of church fires, showing per cent of known locations.

Discovery of Fires.

Churches are commonly idle or unattended structures during a considerable portion of the week, and therefore the necessity for means of prompt discovery of any fire is extremely important. It is a sad commentary to indifference that the fire record lacks a single instance of fires discovered by means of an automatic alarm system, with the exception of one fire where the alarm was given by the alarm valve of an automatic sprinkler system through a central supervisory station.

How Fire Was Discovered.

	No. Fires	Per Cent
Outsider	245	60.7
Parishioner	47	11.6
Sexton or janitor	40	9.9
Minister or priest	38	9.4
Policeman	14	3.5
Workman	12	3.0
Organist	4	1.0
Watchman	2	.5
Central station sprinkler alarm	1	.2
Boy Scout	1	.2
Total known	404	100.0
No data	253	
Total	656	


Roof space fire inaccessible to firemen
Organ loft open to roof space
Open partition
Once a basement fire enters partitions, organ loft, or attic space a large loss inevitably results

Manner of spread of typical church fires.

Construction of Churches.

	No. Fires	Per Cent
Brick or stone-joisted or timber	218	54.8
Frame	156	39.2
Brick veneer	17	4.3
Composite brick and frame	7	1.7
Total known construction	398	100.0
Unknown construction	268	
Total	656	

Unfortunately, in spite of effort and expense devoted to providing attractive and imposing appearance for church structures, with few exceptions little thought has been given to fire safe construction. In order to create pleasing interior effects false work is often employed and lack of fire-stopping for partitions and other open spaces appears to be the rule rather than the exception. In the present fire record only two of the structures were reported to be even partially fire-resistive, and in one of these cases a large annex of combustible construction was destroyed.

Fire chiefs invariably acknowledge that church fires are among the most difficult with which they have to contend and at which chances for successful control are most unfavorable. Veteran fire fighters frequently state that once

a fire in a concealed space extends above the reach of their plasterhooks it is almost impossible to uncover and control the blaze. Imposing stone or brick exterior walls are often deceiving, because in many cases interior construction is of wood with open attic, partitions and organ loft. The part played by such concealed spaces in the spread of church fires has been shown by many of the typical fires already described. In addition, a chart is presented to show how fires spread through a typical church structure. The obvious remedy is complete fire-stopping of all concealed spaces which cannot be eliminated, and automatic sprinklers for concealed areas inaccessible to firemen.

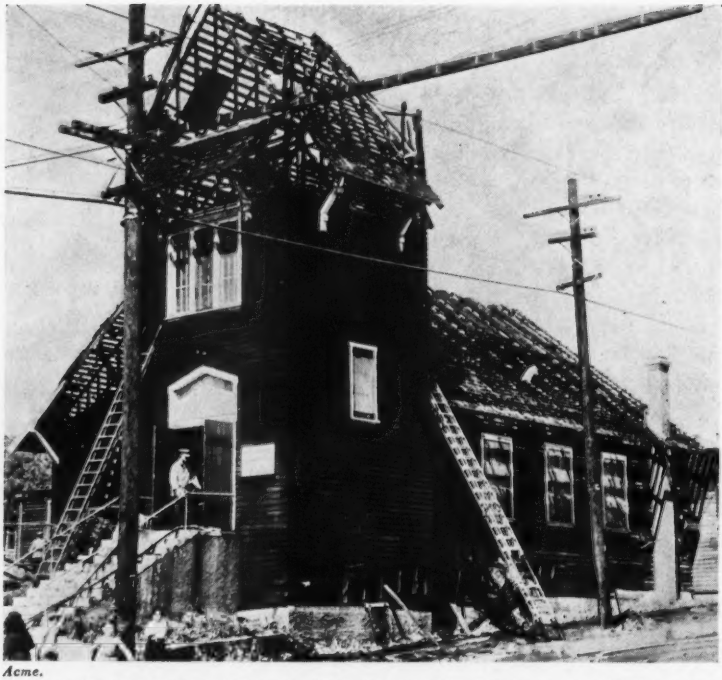
The upsetting of a tray of candles by a small boy worshiper was the cause of the fire which destroyed St. Joseph's Church in Ottawa, with a loss of $418,000 on December 27, 1930.

Automatic Sprinkler Protection for Churches.

Automatic sprinklers have not been installed in churches to a sufficient extent to furnish an experience record for this occupancy comparable with other occupancies, where sprinkler performance shows an average efficiency record of ninety-six per cent. Only eight fires in sprinklered churches have been reported to the N.F.P.A. Department of Fire Record. Of these, six were of such trivial nature that the sprinklers were in no way affected. Two fires worthy of notice in sprinklered churches have occurred as follows:

ST. SAUVEUR CHURCH, QUEBEC, P. Q., OCTOBER 25, 1933. Dead leaves placed in ash room in basement were ignited by hot ashes. One automatic sprinkler operated, gave an alarm over a central station supervisory system and extinguished the fire before any damage was done. (S-64682.)

IMMACULATE CONCEPTION CHURCH, MONTREAL, P. Q. Fire occurred in the peak of the attic while repairmen were working at the roof and tower with charcoal furnaces and soldering irons. The church was equipped with an unapproved partial sprinkler system which included heads in the roof space, although none were located in the peak of the roof where the fire occurred. A hose stream was taken over a ladder and played through holes chopped in the roof, extinguishing the fire before any sprinkler heads in the attic fused. The fire department connected to the sprinkler system to give an added supply if needed. Water from the hose stream flowed through concealed spaces to the basement and caused most of the $50,000 damage. Effective use of salvage covers reduced the damage in the auditorium. (S-64673.)



Acme.

Sparks from the chimney ignited the wooden shingle roof of the Hebron Community Center Church in Los Angeles on March 10, 1935. Flames spread so rapidly that a portion of the roof collapsed shortly after Sunday School children had been led from the structure.

Loss of Life in Church Fires.

While no great catastrophes have occurred in churches of the United States and Canada to cause public concern about the life hazards in this occupancy, the possibility of panic is present as in other occupancies where large numbers of persons gather, and exits should be adequate to care for the maximum number of persons who may meet at one time, and should conform to the N.F.P.A. Building Exits Code requirements for places of public assembly. An indication of what may happen where adequate exits are lacking is given by several disasters which have occurred in other countries. The greatest church fire disaster on record occurred in Santiago, Chile, in December, 1883. In this fire panic occurred and some 2000 persons, comprising the greater part of the congregation, were killed. A more recent disaster occurred in Gaesti, Rumania, on April 18, 1930. A candle ignited a paper wreath and a panic occurred. The doors opened inward and 144 persons were trapped.

New York City recognizes the potential life hazard in churches and requires by law that all churches over forty feet in height must be of fire-resistive construction, fire doors must be provided at all openings, and a minimum of two exits with proper signs is required.

There has been loss of life in at least fourteen church fires in the United States and Canada which are briefly described below.

JACKSON AVENUE EVANGELICAL SUNDAY SCHOOL, NEW ORLEANS, LA., MARCH 7, 1921. Four firemen were killed and one was injured by falling walls when fire destroyed the building. (H-17282.)

HOLY REDEEMER CHURCH, SAN FRANCISCO, CALIF., AUGUST 3, 1922. A woman worshiper was fatally burned when her clothing ignited from a candle. (L-3405.)

CHAPEL OF LATTER DAY SAINTS, TURNER, IDAHO, JANUARY 27, 1927. Six persons were killed and twelve were seriously injured in an explosion of acetylene gas from the lighting system. About two hundred persons were assembled in the frame chapel and recreation hall for a basket-ball game. Someone struck a match, igniting the gas, when the lighting system failed. (H-24199.)

FIRST CONGREGATIONAL CHURCH, TOLEDO, OHIO, FEBRUARY 5, 1927. Three persons who were cleaning the building were killed when an explosion of natural gas escaping from a defective service pipe wrecked the old church building used as a community house. A storm had put electric lights in the city out of service and it is believed that one of the occupants struck a match, igniting the escaping gas. (H-24226.)

CHURCH, ASHEVILLE, ALA., JULY 21, 1930. A child was fatally burned and fourteen other persons were injured when an explosion occurred as an attempt was made to light a gasoline lighting system. (H-30022.)

CAMPBELL A. M. E. CHURCH, WASHINGTON, D. C., JULY 6, 1931. A battalion chief was killed and five other firemen were injured when the roof of the old frame church collapsed during a fire. (H-32876.)

ST. FRANCIS DE ASSISI CHURCH, CAMBRIDGE, MASS., JANUARY 28, 1932. A fireman died in a hospital after being overcome by smoke in a three-alarm fire which caused $20,000 damage in the church. (H-34902.)

RICHEY TABERNACLE, HOUSTON, TEX., FEBRUARY 3, 1932. Four women were in a prayer room on the third floor of a cupola as fire broke out in the church when floor wax, being heated on a gas plate, boiled over. One woman did not leave promptly and was trapped. (H-34479.)

UNITED CHURCH, VANTAGE, SASK., APRIL 16, 1932. Three boys are thought to have been smoking in the building and started a fire. They were burned to death. (H-35399.)

OUR LADY OF LOURDES CHURCH, TORONTO, ONT., JUNE 7, 1933. One fireman was killed and four were injured when an aerial ladder broke while they were fighting a fire in the dome of the church. (L-2123.)

ST. JEROME'S CATHOLIC CHURCH, HOLYOKE, MASS., MARCH 16, 1934. A fire captain died of a heart attack due to overexertion from fighting a fire which destroyed the church with a loss of $280,169. (H-38283.)

CHURCH, QUITMAN, ARK., APRIL 1, 1934. A woman was fatally burned in a fire caused by pouring gasoline on a slow-burning fire in a stove. (L-2625.)

The First Baptist Church of Arlington, Mass., was of substantial construction, as appears from the upper picture. Like many similar structures it gave a semblance of fire safety, which did not in fact exist, as the lower picture, taken after the fire of October 24, 1924, shows. On the rear wall may be seen the partly burned wooden sheathing and the concealed spaces which permitted the rapid spread of fire from basement to roof.

CHURCH, LENNOX, S. D., JULY 12, 1934. The janitor was burning rubbish in the furnace. He used gasoline, which he thought was kerosene, to speed up the fire. He was fatally burned. (H-38951.)

HOLY CROSS MEMORIAL METHODIST CHAPEL, READING, PA., JANUARY 26, 1936. A volunteer fireman died of exposure and exhaustion while fighting a fire which seriously damaged the church. (H-40210.)

Fires in Which There Was Loss of Life.

Second Quarter, 1936.

Since the publication of the April QUARTERLY, the N.F.P.A. Department of Fire Record has received from various sources 238 reports of fires in which there has been loss of life. A total of 402 lives were lost in these fires. The outstanding loss of life fire in the United States during the period covered by this record occurred in connection with the tornado damage at Gainesville, Ga., on April 6, where fifty-seven persons were trapped in the burning ruins of a clothing factory. See report on page 60 of this QUARTERLY. Other fires causing five or more fatalities have occurred during the quarter as follows:

APRIL 5, 1936, NEAR FREDERICKSBURG, PA. Five army aviators were killed when their plane, flying through a rainy mist, crashed into a mountain and burst into flames.

MAY 25, 1936, STAFFORD FORGE, N. J. Five men, including four members of the C.C.C., were burned to death when trapped in a series of forest fires in the "pine barrens" section of New Jersey. The C.C.C. men were trapped when surrounded by a back-fire which they had started while fighting the forest fire.

JUNE 7, 1936, SAN FRANCISCO, CALIF. Seven persons were burned to death when fire, starting in the first floor hallway, swept through a four-story frame hotel, trapping the occupants. Eighteen other persons were injured.

Foreign Fires.

The outstanding loss of life fires occurring outside of the United States and Canada took place in China, where three fires caused large loss of life. While official reports of these fires are lacking, newspaper accounts were supplied through the courtesy of Chief Officer J. G. Dyson of the Shanghai Fire Brigade.

TULIUCHEN, HOPEI, MARCH 17, 1936. A death toll variously reported to be 176 or more persons resulted when fire demolished a native theatre in a town near Tientsin. The theatre was of "matshed" construction, built of sheets of reed-matting on dry bamboo poles, cross members and framework. The reed is a small variety of dried water weed woven into square mats, with a sheet of oiled paper for waterproofing between two sheets of matting. One end of the theatre was located at the bank of a canal and the building had

Causes of Loss of Life, April-June, 1936.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

Cause	Men	Women	Children	No Data	Total
Airplane fires	20	1	0	0	21
Automobile and truck fires	8	3	0	4	15
Automobile tank truck	1	0	0	0	1
Boat and ship fires:					
Motorboat explosions and fires	1	0	0	0	1
Ship fires (see also flammable liquids, gasoline tank vessels)	2	0	0	0	2
Children alone in house	0	0	15	0	15
Children playing with matches	0	0	4	0	4
Clothing ignited:					
Bonfire, grass or rubbish fire	3	0	2	0	5
Electric plate	0	1	0	0	1
Fireplace or open grate	0	1	0	0	1
Flammable cement ignited	1	0	0	0	1
Furnaces, stoves and heaters	3	10	6	0	19
Smoking (see also smoking in bed)	7	0	0	0	7
No data—clothing ignited	1	2	0	0	3
Entering or re-entering burning buildings	5	4	0	0	9
Escaping from fire—jumped or fell	1	1	0	0	2
Explosions (miscellaneous):					
City gas (including appliances)	2	2	1	0	5
Fireworks factory	1	0	0	0	1
Fire fighting—civilians	2	0	0	0	2
Fire fighting—firemen	2	0	0	0	2
Fighting forest or brush fires	6	0	0	0	6
Flammable liquids and vapors:					
Gasoline lamp explosion	0	0	1	0	1
Gasoline tank vessel	3	0	0	0	3
Gasoline vapor ignited by match or pipe	2	0	0	0	2
Home dry cleaning	0	6	2	0	8
Other cleaning with gasoline	1	3	0	0	4
Oil lamp or stove	3	4	4	0	11
Oil refinery	2	2	0	0	4
Oil well	2	0	0	0	2
Starting fires with gasoline	6	4	5	0	15
Starting fires with kerosene	4	5	7	0	16
Starting fire with motor oil	0	0	1	0	1
Turpentine near stove	1	0	0	0	1
Overcome by smoke—suffocation	18	4	7	0	29
Overexertion or excitement	0	1	0	0	1
Response to alarms	5	0	0	0	5
Smoking in bed (see also clothing ignited)	2	1	0	0	3
Suicide—remorse over fire damage	1	0	0	0	1
Trapped in burning buildings	44	34	24	5	108
Trapped in burning tornado débris	0	0	0	57	57
Trapped in incendiary fires	5	2	0	0	7
No data	0	0	1	0	1
Total	165	90	81	66	402

high side walls without exits. The fire spread rapidly and cut off the escape of the occupants from the front entrance.

KONGMOON TO YUEHCHENG KWANGTUNG, MARCH 17, 1936. Approximately three hundred pilgrims lost their lives as the result of a fire starting

aboard a passenger junk proceeding from Kongmoon to Yuehcheng. The victims were mostly women who were taking an organized trip to Yuehcheng to worship "the mother of the dragon." All together nine hundred passengers were traveling in eight junks towed by two steam launches. Three junks were involved in the fire, which was caused by a careless pilgrim burning joss paper on the deck of one of the vessels.

SHEKTSENG ARSENAL, TAI WAN BRIDGE, CANTON, APRIL 11, 1936. Early reports stating that one hundred persons had lost their lives in an arsenal explosion and resulting conflagration appear to have been exaggerated, although many persons were injured and an unknown number of lives were lost. The fire started in a charcoal shop when a cigarette was dropped in a pile of paper and spread to an adjoining toothpick factory. From these buildings the fire spread to a government arsenal containing 1755 barrels of gunpowder and saltpeter. Most of the residents of the section were warned in time to escape the series of explosions which followed ignition of the arsenal. Following the explosions the fire destroyed over one hundred and fifty buildings covering seven blocks.

Loss of Life Fires, April-June, 1936.*

This is a typical rather than a complete record, presented to show the conditions under which loss of life occurs, that they may be known and guarded against. The total loss of life by fire in the United States is estimated at 10,000 annually.

Fires in Buildings:	No. Fires	Men	Women	Children	No Data	Total
Apartments, hotels, lodgings, tenements, etc.	13	8	9	3	5	25
Barns and stables	5	5	0	0	0	5
Dwellings—Rural	56	38	21	32	0	91
Dwellings—Urban	104	36	48	41	0	125
Fireworks	1	1	0	0	0	1
Garages	3	3	0	0	0	3
Gasoline filling stations	2	1	1	1	0	3
Institutions, schools, etc	1	0	1	0	0	1
Manufacturing occupancies	4	3	0	0	57	60
Mercantile occupancies	2	4	0	0	0	4
Other known buildings	7	8	2	0	0	10
Prisons or jails	1	1	0	0	0	1
Restaurants and night clubs	2	2	2	1	0	5
Fires Outside of Buildings:						
Airplanes	10	20	1	0	0	21
Automobiles and trucks	5	8	3	0	4	15
Tank trucks	1	1	0	0	0	1
Forest or brush fire	2	6	0	0	0	6
Oil well	1	2	0	0	0	2
Oil refinery	1	2	2	0	0	4
Out-of-door fires (bonfires, etc.)	7	4	0	3	0	7
Ships and boats	5	5	0	0	0	5
Tankers and barges	1	3	0	0	0	3
Response to alarms	4	4	0	0	0	4
Total	238	165	90	81	66	402

*This table is made up from those reports received by the Department of Fire Record between March 15, 1936, and June 21, 1936. A few of the fires included herein occurred prior to March 15, but were not reported until subsequent to that date.

Typical Loss of Life Fires.

Children Alone in House.

L-3569. CAMPBELLTON, N. B., MARCH 25, 1936. Three children, all less than three years old, were burned to death when trapped in their cabin home. While the mother had gone out for water a stove exploded, starting the fire. Upon seeing the flames the mother ran to the house but was unable to open the door, which she had carelessly latched as she left.

L-3573. SUNBURY, PA., APRIL 9, 1936. Three children, the oldest three years old, were burned to death by a fire of undetermined origin while alone in the house. Their father was at work and the mother was at a neighbor's home.

Children and Matches.

L-3570. PELHAM MANOR, N. Y., MARCH 27, 1936. A four-year-old girl died in a hospital of burns suffered while playing with matches on the sun porch of her home. The child was found with her dress on fire by her grandmother, who heard the girl screaming.

L-3590. LYNN, MASS., MAY 30, 1936. A three-year-old boy was burned to death when his clothing ignited while playing with matches. His mother rolled the child in a rug to smother the flames, but failed to prevent fatal burns.

L-3591. WINCHESTER, VA., JUNE 3, 1936. A nineteen-months-old girl died in a hospital from burns received while playing with a box of matches. The child's clothing was almost burned off before the fire was extinguished.

Clothing Ignited — Burning Grass.

L-3578. SINAI, S. D., APRIL 22, 1936. Burns received while burning dried grass on the lawn of his home proved fatal to a 77-year-old farmer. The victim was unable to attract attention until his clothes were a mass of flames, when a niece saw him and put out the fire.

L-3584. HOLDEN, MASS., MAY 8, 1936. An elderly man was burned to death when a fire, which he started to burn brush, got beyond his control. He collapsed while fighting the flames, and his clothing was ignited.

Dry Cleaning.

L-3572. CORWITH, IOWA, APRIL 8, 1936. A woman was fatally burned and a daughter was injured when gasoline vapor ignited from an unknown cause while gasoline was being used to clean clothing.

L-3574. CINCINNATI, OHIO, APRIL 11, 1936. A woman was fatally burned while cleaning ties with gasoline in her home. Gasoline vapor was ignited from the kitchen stove.

L-3576. LYNN, MASS., APRIL 18, 1936. A man was fatally burned when he placed a can of turpentine containing paint brushes, which needed cleaning, on the kitchen stove. The turpentine ignited and, while attempting to throw the can out of doors, fire spread to the victim's clothing. A son and two policemen rolled the man in a rug, but he was fatally burned.

L-3586. BROOKLYN, N. Y., MAY 14, 1936. The excitement of seeing a neighbor run to the street with her clothes aflame caused the death by a heart attack of a sixty-five-year-old woman. The neighbor, who was only slightly burned, was ironing a dress which she had previously cleaned with gasoline. The dress caught fire and ignited the clothing she was wearing.

L-3587. HULL, P. Q., MAY 18, 1936. A woman was fatally burned when a can of cleaning fluid caught fire and ignited her clothing. She wrapped herself in blankets in an unsuccessful attempt to extinguish the fire and was unconscious when firemen arrived.

Gasoline Stove Explosion.

L-3577. KINGMAN, KAN., APRIL 20, 1936. A seventeen-months-old girl was burned to death when a gasoline stove exploded in her home. The explosion occurred as the child's mother was refilling the stove while it was in operation. The child was sitting in a high chair near by. The mother also was severely burned.

Oil Stove Fires.

L-3566. GRAND RAPIDS, MINN., MARCH 22, 1936. A sixteen-year-old boy was burned to death and his father and elder brother were severely burned by an early morning fire caused by a portable oil stove which was kept burning in a bedroom. At 3 A.M. it was found that the stove was out of control. The father attempted to carry the stove downstairs with a poker through the handle. The handle came off and the stove fell down the stairs, spreading the fire and cutting off the escape of two sons upstairs. They were badly burned before they could jump through a window.

L-3588. SAYREVILLE, N. J., MAY 29, 1936. An eighteen-year-old girl died in a hospital of burns received in an explosion which occurred when she attempted to operate a kerosene oil stove with gasoline. The victim's mother put out the flames by wrapping her daughter in blankets.

L-3589. WATERTOWN, N. Y., MAY 29, 1936. A man and his four-year-old son were burned to death by a fire resulting from an oil stove explosion. A guest in the house saved three other children by dropping them from a window.

Saving Life or Property.

L-3567. CHARLOTTESVILLE, VA., MARCH 24, 1936. A woman lost her life when she rushed to the attic to save her belongings when fire broke out in her home. Firemen who found her body at the top of the attic stairs attributed her death to asphyxiation, although she was subsequently burned.

L-3580. LEOMINSTER, MASS., APRIL 27, 1936. A young society matron died of suffocation while attempting to save antiques from the attic of an unoccupied house which had formerly been her home. The fire occurred in a barn adjoining the house and did not spread to the house. The woman's body was found in the attic after she had been ordered out of the house several times by firemen.

L-3593. RAYNHAM, MASS., JUNE 9, 1936. A woman was trapped and burned to death when she entered her blazing home in an effort to save a daughter from an early morning fire. The parents and one daughter had escaped and found that another girl was not with them. As the mother ran inside and was trapped, the daughter whom she intended to save escaped by jumping from a window.

Suicide Following Fire.

L-3575. CARTHAGE, S. D., APRIL 13, 1936. Grieved because he had started a disastrous fire while burning thistles, a middle-aged farmer ended his life with a shotgun. The fire consumed all the buildings except the dwelling on the farm which he had rented. In addition to destroying his hay, grain, and live stock, the fire extended to stubble and haylands of other farms and an adjoining dwelling was ignited.

Trapped in Burning Buildings.

H-40225. SAN FRANCISCO, CALIF., MAY 13, 1936. Two men and two women lost their lives and twelve other persons were injured by fire and panic which occurred in a night club when a lighted torch in the hands of a torch dancer ignited combustible cloth decorations festooning the ceiling. Windows were boarded up and only one narrow exit was available from the second floor room, where the fire occurred.

H-40854. DETROIT, MICH., MAY 17, 1936. Two men and a woman were trapped and burned to death and four others were injured when fire occurred in an amusement park concession known as the "Jungles." The building, which was one hundred and fifty feet square, contained a maze of passages decorated with artificial grass, shrubs, trees and stuffed animals. The victims were unable to escape when fire put out the lights.

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Class II, Group G Atmospheres containing grain dust.	Flour mills, feed mills, grain elevators, starch plants, sugar cocoa and coal pulverizing plants and establishments or industries involving similar hazardous processes or conditions.	
Class III Locations in which easily ignitible fibres or materials producing combustible flyings are handled, manufactured or used and which are hazardous through such fibres or flyings collecting on or being ignited by arcing contacts, resistors, lamps or similar apparatus.	Cotton and other textile mills, combustible fibre manufacturing plants, cotton gins, clothing manufacturing plants, cotton-seed mills, wood-working plants, and establishments or industries involving similar hazardous processes or conditions.	
Class IV Locations in which easily ignitible combustible fibres are stored or handled and which are hazardous through such fibres being ignited by arcing contacts, resistors, lamps, or similar apparatus.	This class may include locations such as warehouses in which are stored or handled combustible fibres such as cotton (including cotton linters and cotton waste), sisal or henequin, ixtle, jute, hemp, tow, cocoa fibre, oakum, baled waste, kapok, Spanish moss, excelsior, and other similarly readily ignitible fibres.	

Complete descriptions and illustrations of the items listed above as well as of other Benjamin lighting products for hazardous locations are contained in Bulletin on Explosion Proof and Dust Tight Equipment. A postcard will bring you a complimentary copy by return mail.

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The Volunteer Fire Company

By William Draper Brinckloe

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Books and Bulletins

The author of this new book describes himself as "an old volunteer fireman from a very old company." Mr. Brinckloe was the leading spirit in the organization of the Volunteer Firemen's Section of the N.F.P.A. Written for the use of volunteer fire companies, private fire departments, farmers' organizations, civic organizations, women's clubs, firemen's schools, insurance men and citizens generally, *The Volunteer Fire Company* is not in any sense a textbook, but an intensely interesting story of volunteer fire departments and volunteer firemen. A dozen leading fire protection engineers who reviewed the manuscript for technical accuracy all reported they found the text as interesting reading as a good novel and could not put it down until they had read every page. Mr. Brinckloe, as President of the Easton, Maryland, Fire Department, the Maryland State Firemen's Association and other fire fighting organizations, a member of the American Institute of Architects, the American Society of Agricultural Engineers, the American Legion and other organizations and a writer of national reputation, presents this story which is at once fascinating reading and technically accurate. The book is sponsored by the Committee on Farm Fire Protection of the National Fire Protection Association, which has reviewed it and finds all its recommendations consistent with the official standards of the Association.

The book is an attractive cloth bound volume of 168 pages with 24 illustrations of volunteer fire department apparatus, equipment and fire fighting methods. The book is published by the National Fire Protection Association at the nominal charge of $1 per copy, postpaid.

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Look at the 15-year record of the automatic sprinkler industry and there you will find the name VIKING and that of its founder, Col. E. Tyden, indelibly identified with every progressive step.

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Today, as always, Viking offers for every type of risk in industry automatic sprinkler protection that is unsurpassed in efficiency, the last word in modern design and construction; and sold on the Viking Finance Plan, which makes it unnecessary for anyone to delay the installation of this needed equipment. Write for booklets containing complete information.

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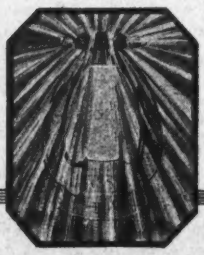

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